Signal Conditioning

SCC Series User Manual

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The following conventions are used in this manual:

<>	Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, DBIO<3..0>.
♦	The ♦ symbol indicates that the following text applies only to a specific product, a specific operating system, or a specific software version.
	This icon to the left of bold italicized text denotes a note, which alerts you to important information.
	This icon to the left of bold italicized text denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.
italic	Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.
SCC	SCC refers to an SCC Series signal conditioning module unless otherwise noted.
SC-2345 connector block	SC-2345 connector block refers to the SC-2345 signal conditioning connector block with a strain relief.
SC-2345 configurable connector	SC-2345 configurable connector refers to the SC-2345 signal conditioner with either rear cable connections or side cable connections.
SC-2345	SC-2345 refers to both the SC-2345 connector block and configurable connector.

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Figures

Tables

1 Introduction

This manual describes the electrical and mechanical aspects of the SC-2345 shielded carriers and the SCC Series modules, and contains information concerning their operation, installation, and configuration.

The SC-2345 shielded carriers have one of the following power modules factory installed:

- SCC-PWR01
- SCC-PWR02 and PS01 power supply
- SCC-PWR03

The SCC Series modules include the following:

- SCC-A10 voltage attenuator (buffered)
- SCC-AI isolated analog input
- SCC-CI20 current input (buffered)
- SCC-ICP01 Integrated Circuit Piezoelectric (ICP®) input
- SCC-LP lowpass filter
- SCC-RTD resistance-temperature detector input
- SCC-SG strain-gauge
- SCC-TC thermocouple input
- SCC-FT01 feedthrough
- SCC-DI01 isolated digital input
- SCC-DO01 isolated digital output

About the SC-2345 and SCC Modules

This chapter describes the SC-2345 shielded carriers and the SCC Series modules, lists what you need to get started, and explains how to unpack your SC-2345 and SCC Series modules.

The SC-2345 connects signals to 68-pin E Series DAQ devices. Combined with the SCC Series modules, the carrier offers easy-to-use signal conditioning options on a per channel basis. The SC-2345 carrier provides 42 screw terminal connections to the E Series DAQ device digital signals. When used with a shielded 68-pin cable, the SC-2345 provides rugged, low-noise signal conditioning.

The SC-2345 is available in the following form factors:

- SC-2345 connector block
- SC-2345 configurable connector with rear cable connection
- SC-2345 configurable connector with side cable connection

The SC-2345 connector block requires you to pass your input signals through a strain relief. The SC-2345 configurable connectors maximize your I/O flexibility through the use of panelettes. All SC-2345s are portable enclosures for laptop and desktop applications.

Purchasing the optional rack-mount or stack-mount accessories allows you to mount the SC-2345 configurable connector to suit your application. The rack-mount option is available for standard 19 in. racks.

SCC modules are signal conditioning modules used in an SC-2345 connected to your 68-pin E Series DAQ device. The SCC modules add voltage attenuation, current input, thermocouple input, and 24 V digital input and output functionality to your E Series DAQ device. A feedthrough SCC allows direct connection to the analog input or analog output signals. You can customize this feedthrough module to meet your specific signal conditioning needs by placing your circuitry design inside the feedthrough module.

What You Need to Get Started

To set up and use the SC-2345 and the SCC modules, you need the following items:

- ❑ SC-2345 with one of the following:
  - – SCC-PWR01
  - – SCC-PWR02 and the PS01 power supply
  - – SCC-PWR03 and a 7 to 42 VDC power supply
- ❑ One or more of the following SCC modules:
  - – SCC-A10
  - – SCC-AI
  - – SCC-CI20
  - – SCC-ICP01
  - – SCC-LP
  - – SCC-RTD01
  - – SCC-SG
  - – SCC-TC
  - – SCC-FT01
  - – SCC-DI01
  - – SCC-DO01
- ❑ *SCC Series User Manual*
- ❑ SC-2345 Quick Reference Label
- ❑ 68-pin E Series DAQ device, documentation, and 68-pin cable
- ❑ Flathead screwdriver (supplied)
- ❑ Number 1 and 2 Phillips-head screwdrivers
- ❑ Wire insulation strippers
- ❑ NI-DAQ (current version) for Windows NT/2000/9*x*

Note The Macintosh operating system currently is not supported.

♦ SC-2345 configurable connector

To use this carrier you need the following items in addition to those previously listed:

❑ Rack-mount kit (optional)

❑ Stack-mount kit (optional)

❑ One or more I/O panelettes and label sheet

Unpacking

Your shielded carrier is shipped in a cardboard box. The SCC modules are shipped in antistatic packaging to prevent electrostatic damage to the modules. Electrostatic discharge can damage several components on these products. To avoid such damage when you handle the products, take the following precautions:

- Ground yourself by using a grounding strap or by touching a grounded object.
- Touch the antistatic package to a metal part of your computer chassis before removing the modules from the packaging.
- Remove the modules from the packaging and inspect the modules for any sign of damage. Notify National Instruments if the modules appear damaged in any way. Do *not* install a damaged module into your system.
- *Never* touch the exposed pins of connectors.

Installing NI-DAQ and Your DAQ Device

Install the NI-DAQ driver software before installing your E Series DAQ device. See the *DAQ Quick Start Guide* provided with your DAQ device for instructions.

The SC-2345 requires NI-DAQ. See Table 1-1 to determine which version of NI-DAQ is required for your application. If you need a newer version of NI-DAQ, go to the `ni.com` Web site and follow the links **Download Software»Drivers and Updates»NI-DAQ** to find the version of NI-DAQ required for your application.

Table 1-1. Minimum NI-DAQ Version Required

SCC Module	NI-DAQ Version (or later) Required
SCC-A10	6.0
SCC-AI	6.6
SCC-CI20	6.0
SCC-ICP	6.8
SCC-LP	6.1
SCC-RTD	6.8
SCC-SG	6.6
SCC-TC	6.0
SCC-FT01	6.0
SCC-DI01	6.1
SCC-DO01	6.1

Configuration

Run Measurement & Automation Explorer to configure your SCC system. If you need help during the configuration process, open the Measurement & Automation Help file by selecting **Help Topics** from the **Help** menu. Follow these steps to configure your SCC system:

1. Double-click the **Measurement & Automation Explorer** icon on your desktop.
2. Display the list of devices and interfaces by clicking the **+** next to the **Devices and Interfaces** icon.
3. Right-click on the appropriate E Series DAQ device you will connect to and select **Properties**.
4. Select the **Accessory** tab.
5. Under **Accessory:** select **SC-2345**.
6. Select the **Configure** button. A new window appears listing the slots (connector reference designators) of the SC-2345.
7. Select the connector of the SC-2345 where you have installed a SCC.

8. Click **Add** and select the SCC you have installed. If the SCC name you have installed does not appear in the list, the SCC is not allowed in that location. If you make a mistake in selection, select the connector and click **Remove.**
9. Click **OK** after completing all SCC entries.
10. Click **OK** to complete the configuring process and close **Measurement & Automation Explorer.**

Note By configuring the SCC system, NI-DAQ performs the appropriate scaling for each SCC. If you are configuring analog input SCCs, the configuration automatically sets the E Series analog input mode to NRSE. If you are configuring DIO SCCs, the configuration automatically sets individual DIO lines to the appropriate input or output mode.

After properly configuring the SC-2345 as a DAQ device accessory in Measurement & Automation Explorer, NI-DAQ does the scaling required for each SCC type. Refer to the *Measurement Scaling Considerations* section of your SCC module, in Chapter 4, *SCC Series Modules*, for more information.

2

SCC-PWR Modules

This chapter describes the SCC-PWR module options, how to select the correct SCC-PWR for your application, and important safety information.

The SCC-PWR modules are a required part of the SC-2345 system. Your SC-2345 ships with one of three SCC-PWR modules factory installed. The power module options are: SCC-PWR01, SCC-PWR02, and SCC-PWR03.

Each power module supplies digital power (+5 V) and analog power (±15 V) to each SCC module in the SC-2345 carrier. LEDs on the SC-2345 indicate whether the +5 V and ±15 V power supplies are functioning properly. Use Table 2-1 to determine the SCC-PWR module that best suits your needs.

Note Appendix B, *SCC Feature Reference Table*, summarizes the power requirements of all SCC modules. Use this to calculate a power requirement budget for your application.

Table 2-1. Power Module Usage

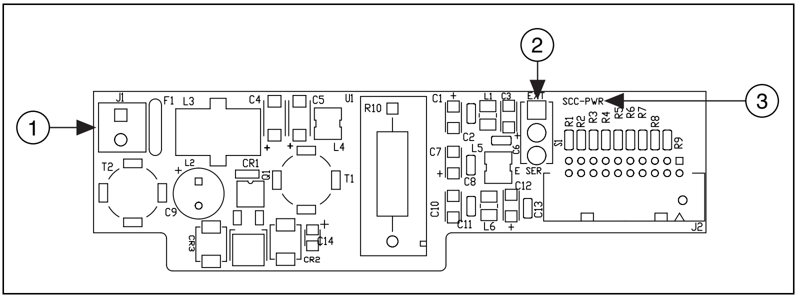
Power Module	Power Source	Usage Suggestions
SCC-PWR01	5 V from E Series DAQ device	Total P_A consumption ≤ 1.5 W *and* total SCC module power consumption within the limits of your E Series DAQ device
	5 V from external supply	Total P_A consumption ≤ 2 W *and* total SCC module power consumption exceeds the limits of your E Series DAQ device

Table 2-1. Power Module Usage (Continued)

Power Module	Power Source	Usage Suggestions
SCC-PWR02	AC (5 V and ±15 V supplied by included PS01 DC adapter)	SCC-PWR01 is insufficient *or* SCC-PWR03 is insufficient
SCC-PWR03	7 to 42 VDC from external supply	Total P_A consumption ≤ 2 W *and* external supply is 7 to 42 VDC
P_A = analog power		

To change your SCC-PWR module, unplug the SCC-PWR module that is no longer needed and plug in the new module.

Detailed specifications for all SCC-PWR modules are in Appendix A, *Specifications*. Figure 2-1 shows the SCC-PWR module parts locator diagram.



1 J1	2 S1	3 Product Name

Figure 2-1. SCC-PWR Parts Locator Diagram

Safety Information

The following statements contain important safety information concerning hazardous voltages and terminal blocks.

Cautions Do *not* operate the device in an explosive atmosphere or where there may be flammable gases or fumes.

Keep away from live circuits. Do *not* remove equipment covers or shields unless you are trained to do so. If signal wires are connected to the device, hazardous voltages may exist even when the equipment is turned off. To avoid a shock hazard, do *not* perform procedures involving cover or shield removal unless you are qualified to do so and disconnect all field power prior to removing covers or shields.

Equipment described in this document must be used in an Installation Category II[1] environment per IEC 664. This category requires local-level-supply mains-connected installation.

Do *not* operate this equipment in a manner that contradicts the information specified in this document. Misuse of this equipment could result in a shock hazard.

Connections, including power signals to ground and vice versa, that exceed any of the maximum signal ratings on the device can create a shock or fire hazard or can damage any or all of the boards connected to the host computer and the device. National Instruments is *not* liable for any damages or injuries resulting from incorrect signal connections.

Connect the signal wires to the screw terminals by fully inserting the stripped end of the wire into the terminals. Tighten the terminals to a torque of 5 to 7 in.-lb.

Clean devices and terminal blocks by brushing off light dust with a soft nonmetallic brush. Remove other contaminants with deionized water and a stiff nonmetallic brush. The unit must be completely dry and free from contaminants before returning to service.

The chassis ground terminal on your SC-2345 connector block and the electromagnetic interference (EMI) gasket attached to the strain-relief of the SC-2345 connector block are for grounding a floating source (1 mA maximum). Do *not* use these terminals as safety earth grounds.

High voltages are voltages greater than or equal to 30 V_{rms} and 42.4 V_{peak}, or 60 VDC in normal conditions and are deemed to be a shock hazard.

[1] Category II refers to local-level power distribution, such as that provided by a standard wall outlet.

SCC-PWR01

The SCC-PWR01 converts +5 V to ±15 V, which is the analog power supply the SCC modules use. Set switch S1 on the SCC-PWR01 to select the source of the +5 V as either *external* or from the *E Series* DAQ device. If you select E Series, the SCC-PWR01 uses +5 V power from your E Series DAQ device. If you select *external*, you must connect a +5 V supply to the screw terminals of J1 on the SCC. Each screw terminal is labeled +5V or GND and should be wired accordingly. See Table 2-2 for usage information for your type of E Series device.

Table 2-2. SCC-PWR01 Power Usage Guide

Power Source or Device	Power Available or Required	Supported Configurations
AT/PCI E Series PXI DAQPad-6020E DAQPad-6070E	2.4 W available	Up to 12 low-power SCC modules *or* [P_A required ≤ 1.5 W *and* P_D required ≤ 2.4 W – (P_A / 0.62)]
DAQCard DAQPad-MIO-16XE-50	1.14 W available	Up to 6 low-power SCC modules *or* [P_A required ≤ 0.72 W *and* P_D required ≤ 1.14 W – (P_A / 0.62)]
External +5 VDC	Power required = (P_A / 0.62) + P_D	Up to 16 low-power SCC modules *or* total P_A required ≤ 2 W
P_A = total analog power P_D = total digital power When P_A exceeds the above limits, you must use SCC-PWR02. **Note:** The efficiency of the +5 V to analog power converter used on the SCC-PWR01 is 62%. The power available is based on the +5 V fuse rating of the E Series DAQ device.		

SCC-PWR02

The SCC-PWR02 is a two-part system that consists of a desktop power supply (PS01) and a filtering component (SCC-PWR02). The PS01 is a 15 W switching supply powered by 90 to 264 VAC (50/60 Hz 1.0 A). To install the PS01, plug the six-position connector of the PS01 into connector J25 of the SC-2345. See Figure 3-5 for the location of connector J25.

The SCC-PWR02 filtering component filters and passes on +5 V and ±15 V. The SCC-PWR02 provides sufficient power for most SC-2345 configurations. Refer to Appendix A, *Specifications*, for details.

SCC-PWR03

The SCC-PWR03 converts an external voltage of 7 to 42 VDC to +5 V and ±15 V and requires an external DC power source. Attach your voltage source to the screw terminals of J1. Each screw terminal is labeled 7–42 V or GND and should be wired accordingly. You can power the SCC-PWR03 with any 7 to 42 VDC source such as a standard 12 V car battery.

The external power required is calculated as follows:

$$(\textit{total } P_A \textit{ required} / 46.5\%) + (\textit{total } P_D / 75\%)$$

The two supported configurations are as follows:

- Up to 16 low-power SCC modules
- Total P_A required ≤ 2 W

Note The efficiency of the +5 V step-down converter is 75%. The efficiency of the +5 V-to-analog power converter is 62%.

3

Configuring, Connecting, and Installing the SCC Modules

This chapter explains how to configure, connect, and install the SCC system.

Configuring and Connecting the SCC Modules

SCC modules connect to the SC-2345 internal sockets to provide custom signal conditioning options for analog input, analog output, digital input/output (DIO), and general-purpose counter/timers (GPCTRs).

The SC-2345 Quick Reference Label illustrates the possible configurations of the SCC modules and defines the location of each signal on the terminal blocks. The numbers on the label correspond to the pin numbers on the 68-pin E Series connector. You can apply the self-adhesive label to the inside cover of the SC-2345.

The SCC modules and sockets are keyed for proper orientation and are color-coded for easy connections. All SCC modules have a color stripe across the top that indicates its function classification. The SCC modules fit easily into the correct sockets when properly oriented. Never force an SCC into a socket.

Figure 3-1 illustrates the configurations options of the SCC modules on the SC-2345 and shows the color code identification information. The upper section of the figure shows a portion of the SC-2345 Quick Reference Label with a color designation legend under it.

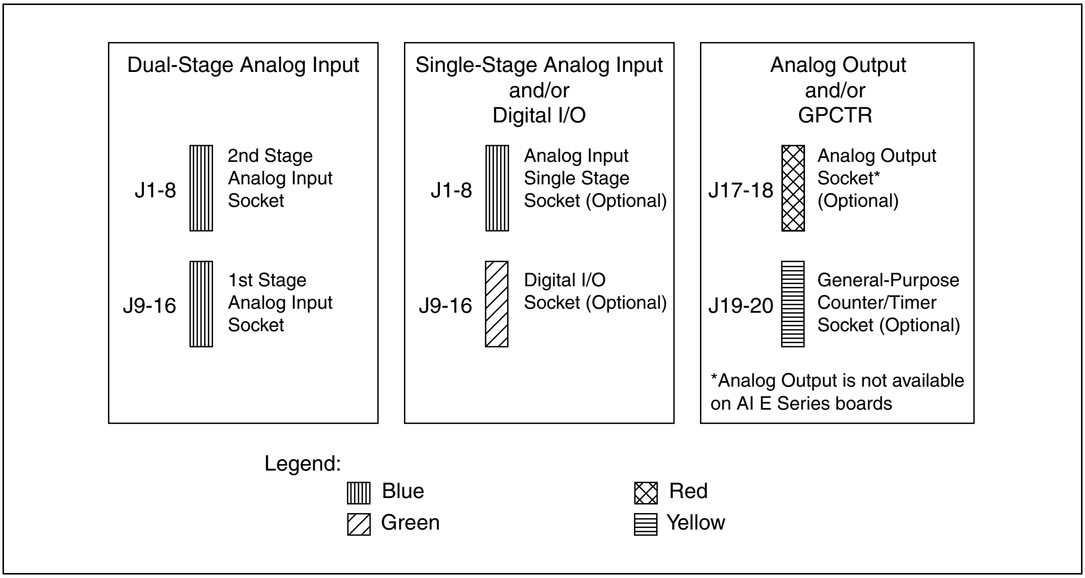


Figure 3-1. SCC Socket Configurations and Color Codes

SCC modules are required for connecting to the analog inputs or analog outputs of your E Series device. You do not need to go through SCC modules to connect to the GPCTR and the DIO signals of the E Series device. GPCTR and DIO signals are accessible at the SC-2345 terminal block. See the *Terminal Block Signal Connections* section later in this chapter for details.

Analog Input SCC Modules

Each analog input SCC label has a blue stripe for easy identification. You can condition analog input signals in two ways: single-stage or dual-stage (cascading) conditioning.

For single-stage input conditioning, plug your SCC modules into sockets J1 to J8 and wire the SCC to your I/O signals.

For dual-stage analog input conditioning, plug the first-stage SCC into sockets J9 to J16 and plug the second-stage SCC into sockets J1 to J8. When using dual-stage analog input conditioning, wire the first-stage SCC to your I/O signals. The SC-2345 connects the output signals of the first-stage SCC to the inputs of the second-stage SCC. An example of dual-stage conditioning is a voltage attenuator SCC followed by a lowpass filter SCC. Cascading options will be useful as a wider variety of signal

conditioning modules, such as different types of lowpass filters, become available.

Sockets J9 to J16 are also available for DIO conditioning or control. If you installed both an analog input SCC and a DIO SCC into the SC-2345, you must wire each SCC separately.

You can use all analog input SCC modules in single-stage analog input configurations. You can use most analog input SCC modules in dual-stage configurations by cascading your SCC modules. Refer to Appendix B, *SCC Feature Reference Table*, to determine correct configurations of each SCC.

DIO SCC Modules

Each DIO SCC label has a green stripe for easy identification. You can plug DIO SCC modules into the SC-2345 using sockets J9 to J16.

Analog Output SCC Modules

Each analog output SCC label has a red stripe for easy identification. You can plug analog output SCC modules into the SC-2345 using sockets J17 and J18. Each socket connects to both analog output channels of the E Series device although identified on the SC-2345 for either channel 0 or channel 1. These designations indicate the primary analog output channel each socket uses. Analog output channel 0 is the primary channel for socket J17. Analog output channel 1 is the primary channel for socket J18.

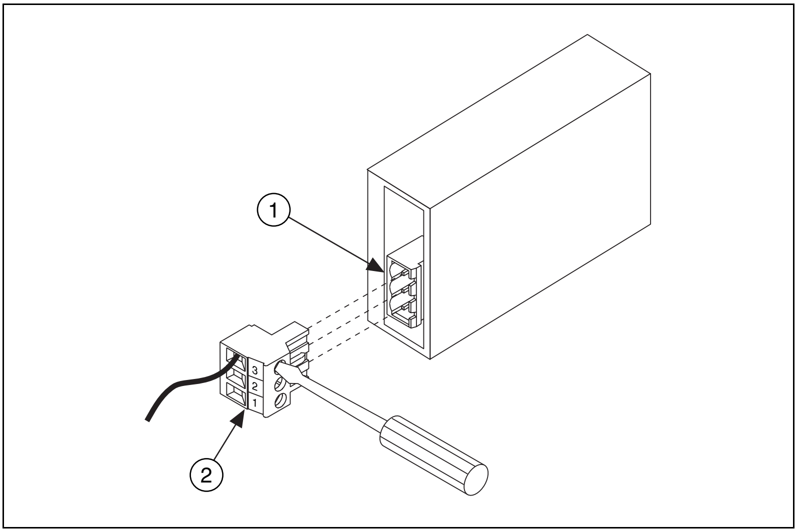
GPCTR SCC Modules

Each GPCTR SCC label has a yellow stripe for easy identification. You can plug GPCTR SCC modules into the SC-2345 using sockets J19 and J20. Socket J19 connects to GPCTR channel 0. Socket J20 connects to GPCTR channel 1.

SCC Signal Connections

After you install the SCC modules, attach your signals to the screw terminals of the SCC modules. Each SCC screw terminal is labeled; wire them accordingly. You can find individual details of signal descriptions and signal connections in Chapter 4, *SCC Series Modules*.

Each SCC screw terminal is a two-part system, with a fixed receptacle and a removable screw terminal, as shown in Figure 3-2.



1 SCC Screw Terminal Receptacle	2 Removable Screw Terminal

Figure 3-2. Two-Part Screw Terminal System

This two-part system simplifies the swapping of similar SCC modules. For example, when using an SCC for filtering on an analog input channel, you can remove the screw terminal from the SCC and plug it into another filtering component with the same pin assignment and you do not need to rewire the screw terminal.

Depending on the module and its function, the two-part system has a different number of terminals and different size terminals. For safety, high-voltage input SCC modules contain larger screw terminals and will not connect to low-voltage input SCC screw terminal receptacles.

Terminal Block Signal Connections

The SC-2345 has a 42-position, triple-row screw terminal block for connection to the E Series digital signals. The terminal block can connect to DIO <0..7>, +5 V, DGND, PFI <0..9>, GPCTR, AISENSE, FREQ_OUT, EXTSTROBE, and SCANCLK. The SC-2345 Quick Reference Label identifies the location of each signal on the terminal rows A to C. The terminal label numbers correspond to the pin number location of each signal on the 68-pin E Series connector. See your E Series device user manual for more information about this connector.

Figure 3-3 shows the location of each signal on the terminal block.

Signal	A	Signal	B	Signal	C
Not Used		*Not Used*		*Not Used*	
Not Used		DGND	35	AISENSE	62
FREQ_OUT	1	DGND	4	EXTSTROBE*	45
GPCTR0_OUT	2	DGND	36	GPCTR1_OUT	40
PFI8/GPCTR0_SOURCE	37	DGND	39	PFI9/GPCTR0_GATE	3
PFI6/WFTRIG	5	DGND	7	PFI7/STARTSCAN	38
PFI4/GPCTR1_GATE	41	DGND	9	PFI5/UPDATE*	6
PFI2/CONVERT*	43	DGND	44	PFI3/GPCTR1_SOURCE	42
PFI0/TRIG1	11	DGND	12	PFI1/TRIG2	10
(+) 5 V	14	DGND	13	SCANCLK	46
DIO6	16	DGND	15	DIO7	48
DIO4	19	DGND	50	DIO5	51
DIO2	49	DGND	18	DIO3	47
DIO0	52	DGND	53	DIO1	17

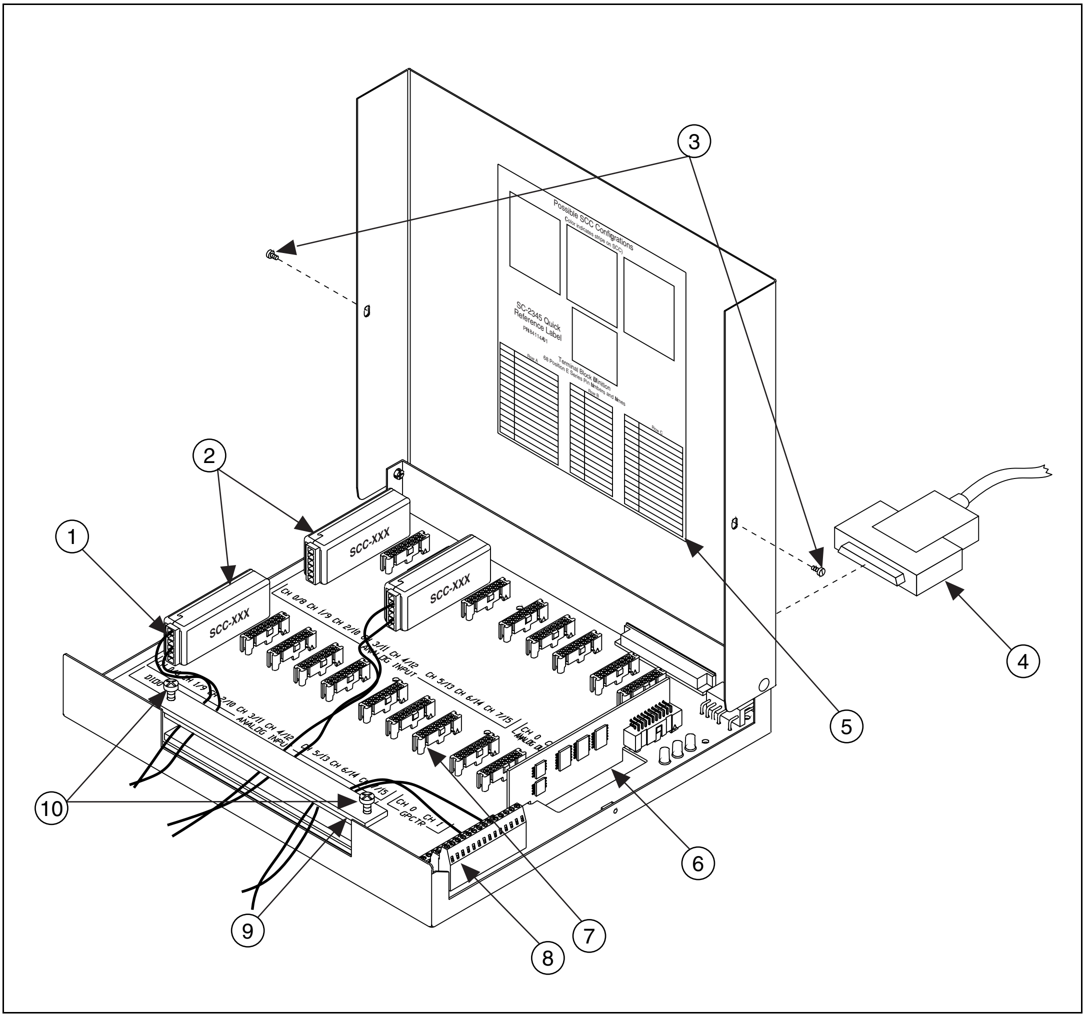
Figure 3-3. Terminal Block I/O Connector Pin Assignments

Installing the SCC Modules into the SC-2345 Connector Block

Refer to Figure 3-4 as you perform the following steps to set up the SC-2345 connector block:

1. Configure your E Series device in nonreferenced single-ended (NRSE) analog input mode. If you use Measurement & Automation Explorer, configure your E Series with the SC-2345 accessory.
2. Connect the 68-pin E Series cable to the SC-2345 connector block.
3. Remove the cover screws on either side of the top cover with a Number 1 Phillips-head screwdriver. Open the top cover.
4. Loosen the strain-relief screws with a Number 2 Phillips-head screwdriver and slide the signal wires through the strain-relief opening. If you are connecting multiple signals, you may need to remove the top strain-relief bar.
5. Plug the SCC components into the appropriate SCC sockets. Refer to the *Configuring and Connecting the SCC Modules* section for proper SCC installation into the SC-2345 connector block.

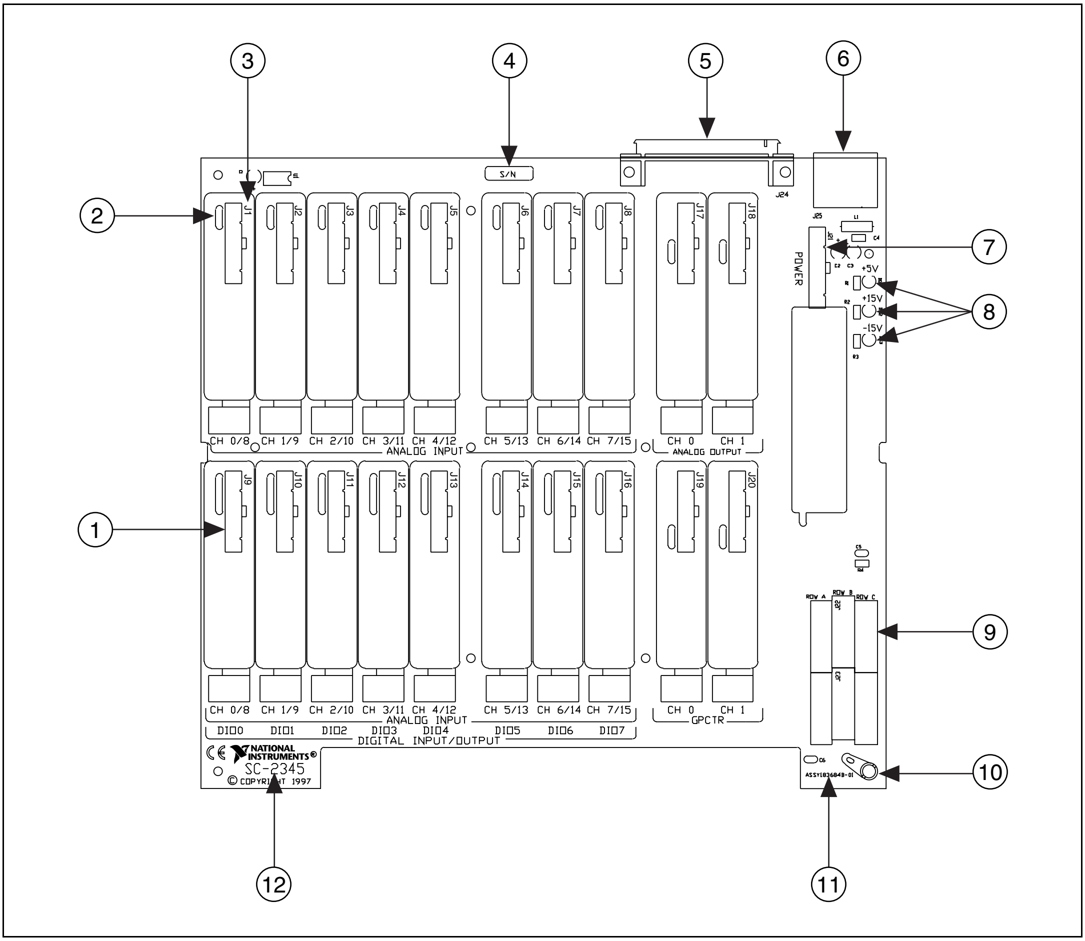
6. Connect your signal wires to the screw terminals and screw terminal block by stripping off 0.25 in. of insulation, inserting the wires into the screw terminals, and tightening the screws. For complete signal connection information, refer to Chapter 4, *SCC Series Modules*.
7. Reinstall the strain-relief bar, if necessary, and tighten the strain-relief screws.
8. Close the top cover.
9. Reinsert the grounding screws to ensure proper shielding.



1 Screw Terminals	4 68-Pin E Series Cable	7 SCC Socket	10 Strain-Relief Screws
2 SCC Modules	5 Quick Reference Label	8 Screw Terminal Block	
3 Cover Screws	6 SCC-PWR*XX*	9 Top Strain-Relief Bar	

Figure 3-4. SC-2345 Connector Block Module Assembly Parts Locator Diagram

Figure 3-5 is the parts locator diagram for the SC-2345 connector block and shows all SCC socket locations.



1 SCC Socket	5 J24	10 Grounding Terminal Lug
2 SCC Key Slot	6 J25	11 Assembly Number
3 SCC Socket Reference Designator	7 J21	12 Product Name
4 Serial Number	8 Power LEDs	
	9 Screw Terminal Block	

Figure 3-5. SC-2345 Connector Block Board Parts Locator Diagram

Figures 3-6 and 3-7 show how to install analog input and DIO SCC modules into the SC-2345 connector block.

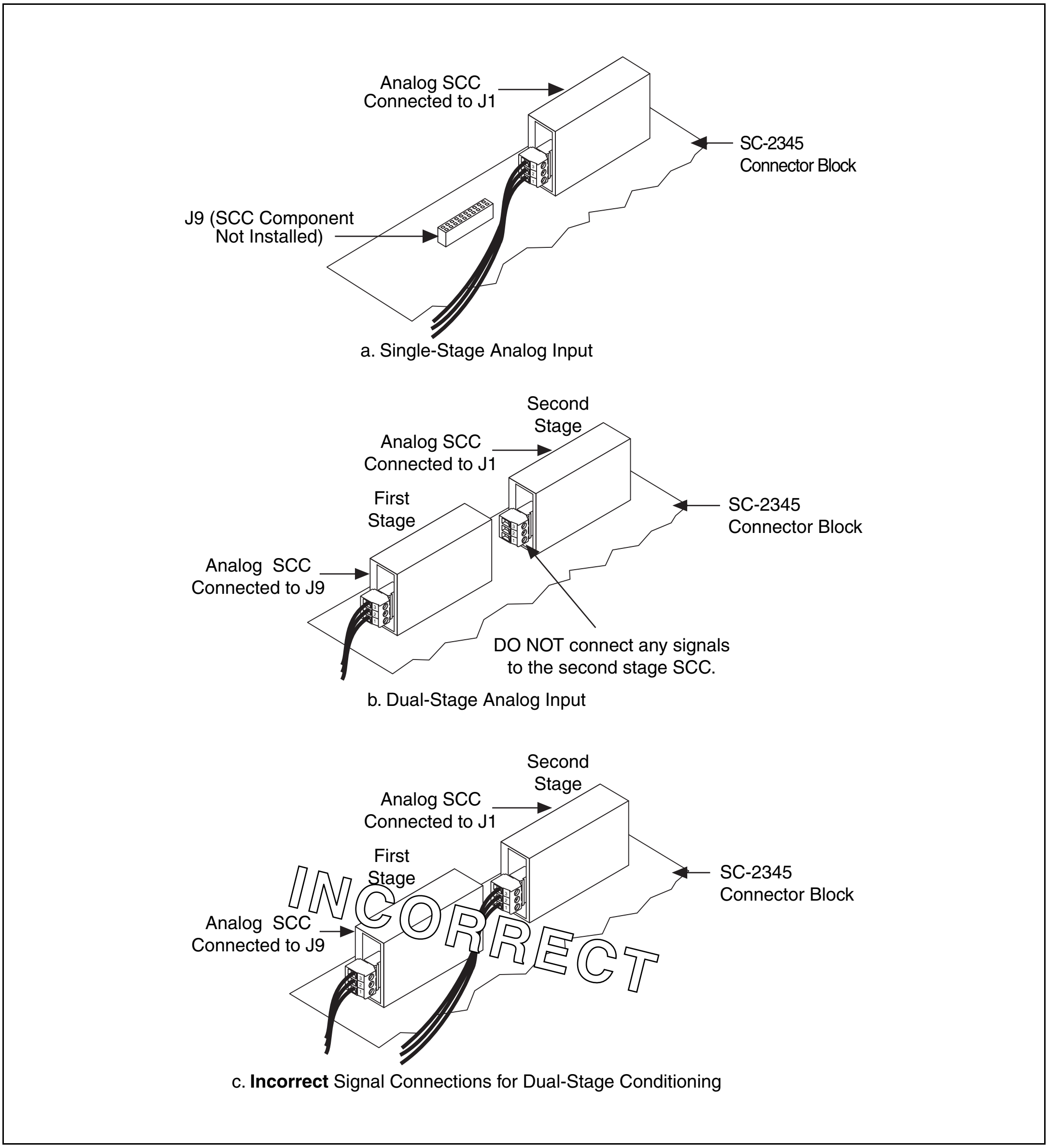


Figure 3-6. Single-Stage and Dual-Stage Analog Input SCC Configuration for SC-2345 Connector Block

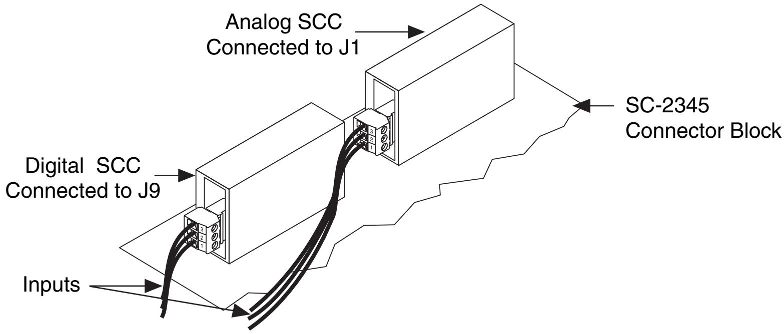


Figure 3-7. Single-Stage Analog Input and DIO SCC Configuration for SC-2345 Connector Block

A metallized nylon knit EMI gasket is attached to the strain-relief bars of the SC-2345 connector block. If you use shielded cables to connect your signals, this allows you to easily ground your shielded signal cables. Stripping the insulation away from the shield of your cables forms a chassis ground connection at the strain-relief bar.

Installing the SCC Modules into the SC-2345 Configurable Connector (Rear Cabled and Side Cabled)

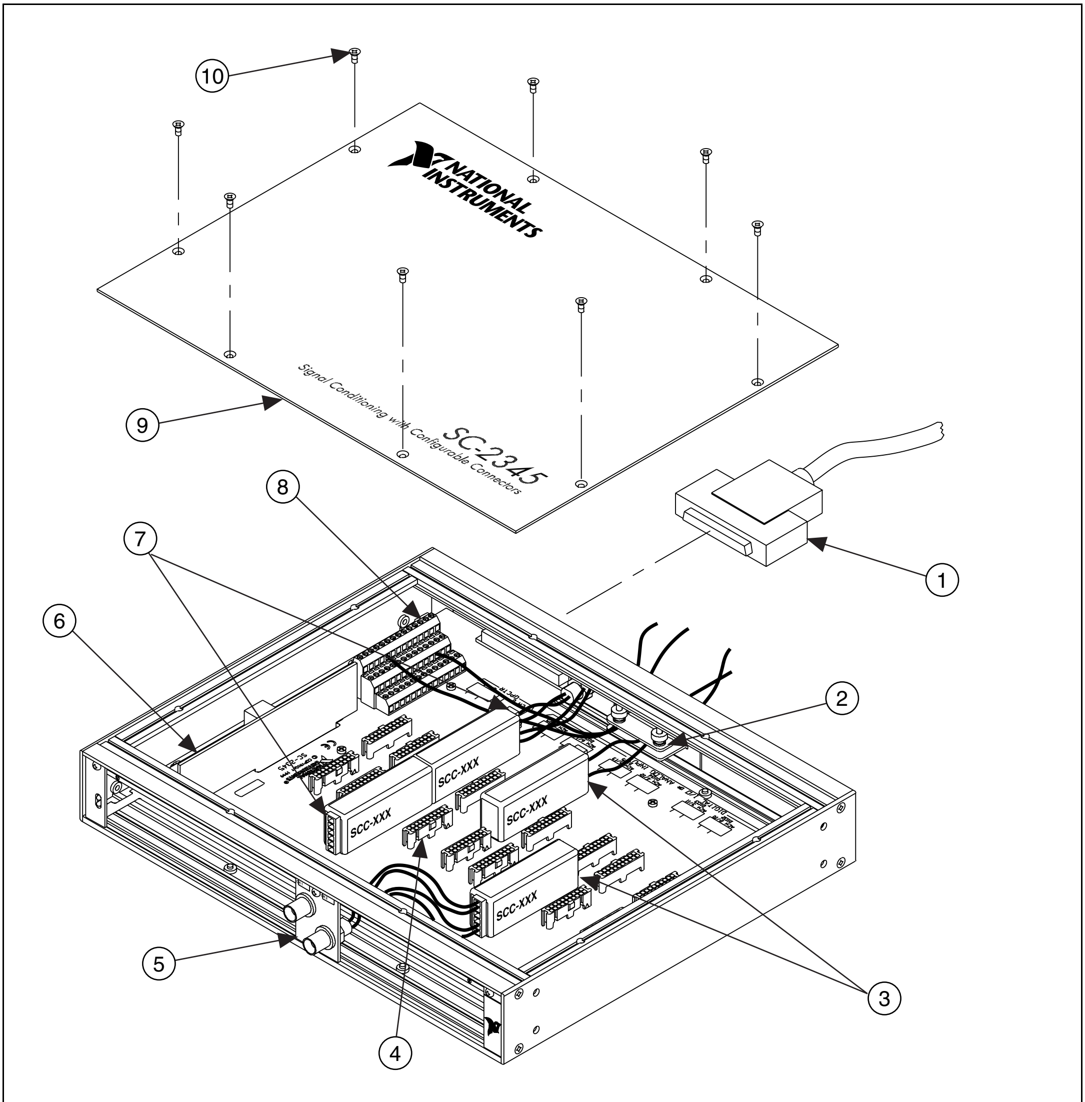
Refer to Figure 3-8 as you perform the following steps to set up the SC-2345 configurable connector (rear cabled) and Figure 3-9 for the SC-2345 configurable connector (side cabled):

1. Configure your E Series DAQ device in NRSE analog input mode. If you use Measurement & Automation Explorer, configure your E Series DAQ device with the SC-2345 accessory.
2. Connect the 68-pin E Series cable to the SC-2345 configurable connector.
3. Remove the eight 4-40 × 1/4 in. flathead Phillips-head screws from the top cover.
4. Remove the top cover.
5. Plug the SCC components into the appropriate SCC sockets. Refer to the *Configuring and Connecting the SCC Modules* section for proper SCC installation into the SC-2345 configurable connector.

6. Install the I/O panelettes:
    a. Place the lower edge of the I/O panelette in the groove at the bottom of the enclosure opening.
    b. Tilt the panelette top back into the enclosure.
    c. Secure the panelette with either one, two, or three (depending on the type of I/O panelette) M2.5 × 6 panhead screws that are included with the panelette.
    d. You must remove the pre-installed rear panel prior to installing any I/O panelettes on the rear of the SC-2345 configurable connector.
    e. Install a blank panelette in any unused panelette opening.
7. Connect your panelette wires to the SCC module screw terminals and screw terminal block by stripping off 0.25 in. of insulation, inserting the wires into the screw terminals, and tightening the screws. For complete signal connection information, refer to Chapter 4, *SCC Series Modules*.

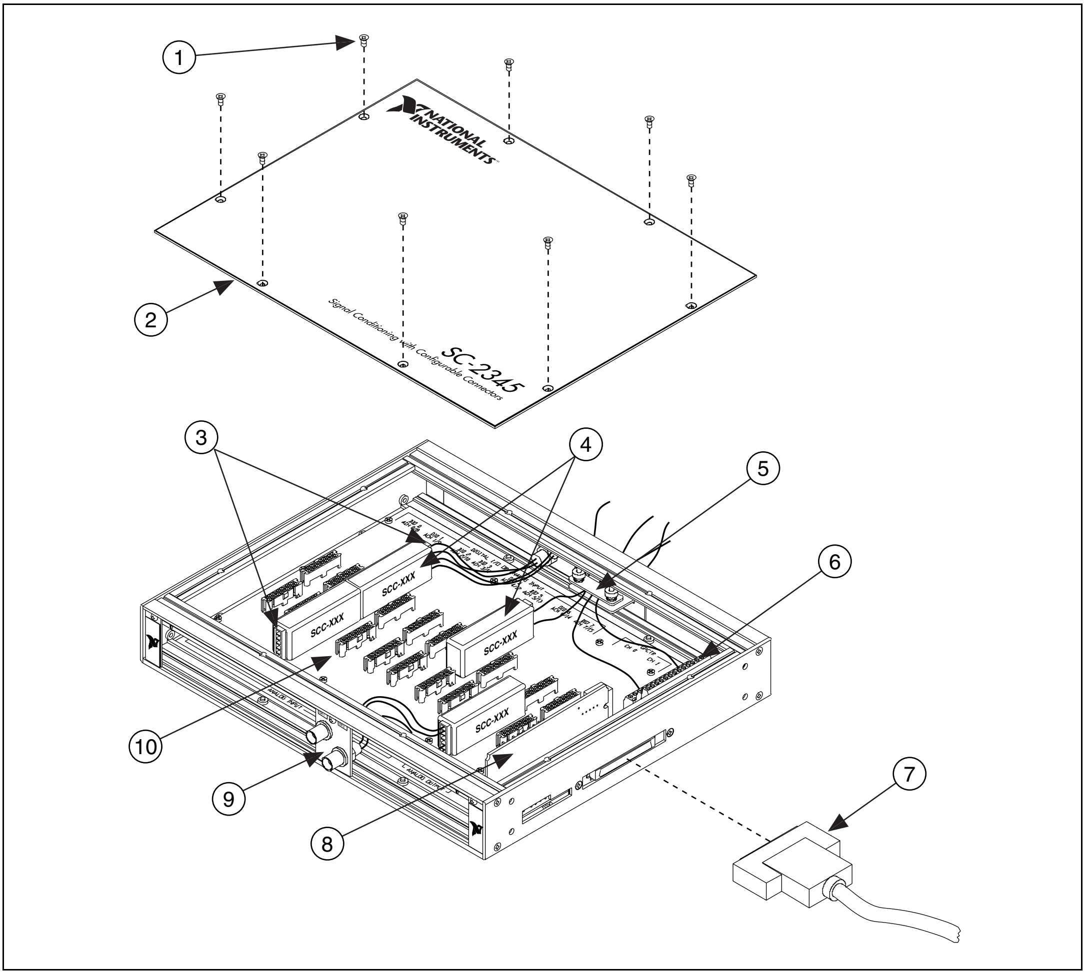
Note If you want to label your panelletes at this time, see *I/O Panelette Labels* later in this chapter.

8. Replace the top cover and install the screws.



1	68-Pin E Series Cable	5	BNC Panelette	9	Top Cover
2	Strain-Relief Panelette	6	SCC-PWR*XX*	10	Cover Screws
3	SCC Modules	7	Screw Terminals		
4	SCC Socket	8	Screw Terminal Block		

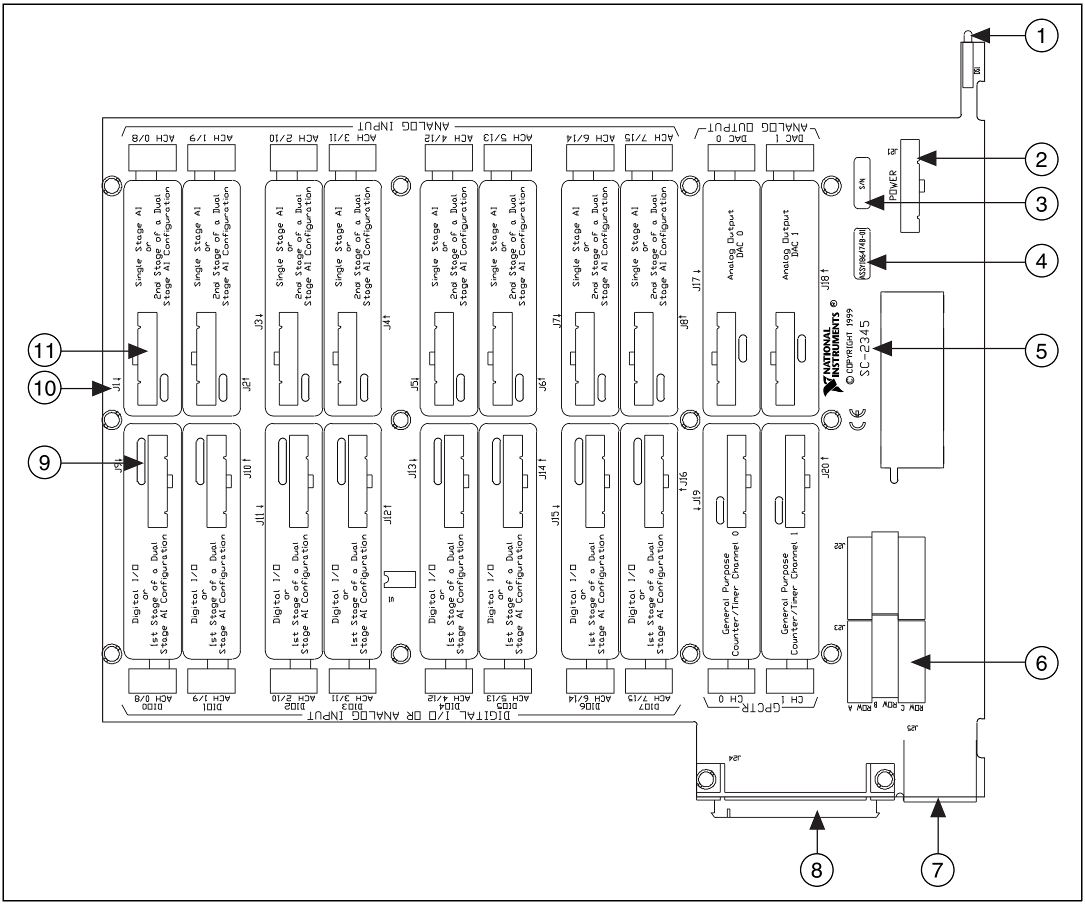
Figure 3-8. Opening the SC-2345 Configurable Connector (Rear Cabled) Enclosure



1 Cover Screws	5 Strain-Relief Panelette	9 BNC Panelette
2 Top Cover	6 Screw Terminal Block	10 SCC Socket
3 Screw Terminals	7 68-Pin E Series Cable	
4 SCC Modules	8 SCC-PWR*XX*	

Figure 3-9. Opening the SC-2345 Configurable Connector (Side Cabled) Enclosure

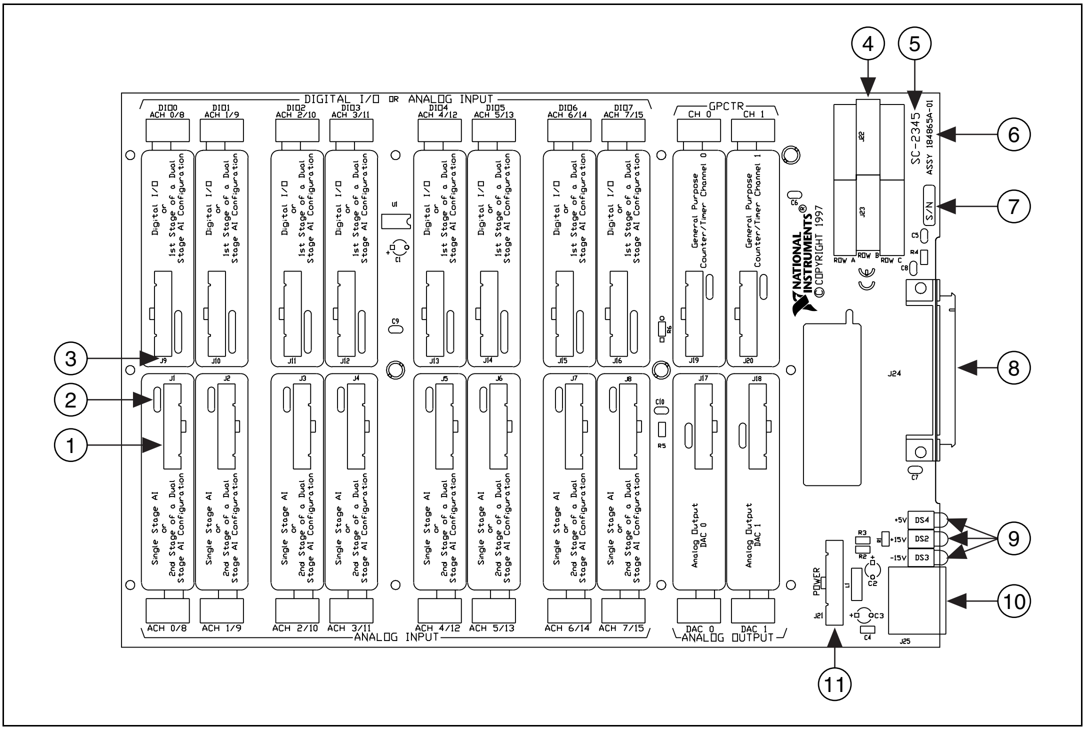
Figure 3-10 shows the SC-2345 configurable connector (rear cabled) socket locations.



1 Power LEDs	5 Product Name	9 SCC Key Slot
2 J21	6 Screw Terminal Block	10 SCC Socket Reference Designator
3 Serial Number	7 J25	11 SCC Socket
4 Assembly Number	8 J24	

Figure 3-10. SC-2345 Configurable Connector (Rear Cabled) Board Parts Locator Diagram

Figure 3-11 shows the SC-2345 configurable connector (side cabled) socket locations.

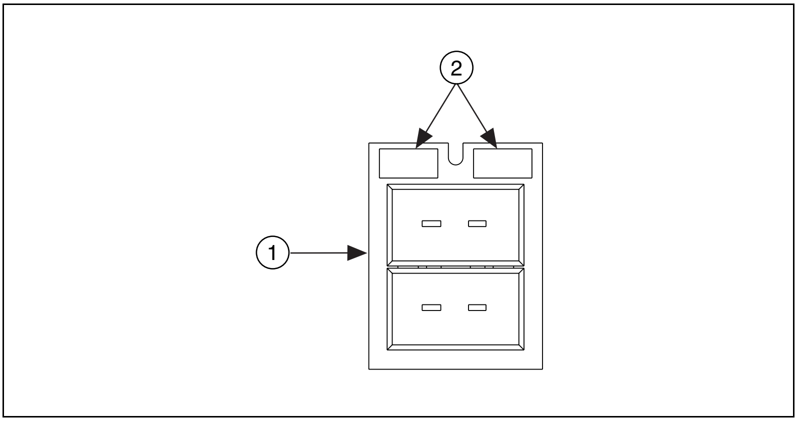


1	SCC Socket	5	Product Name	9	Power LEDs
2	SCC Key Slot	6	Assembly Number	10	J25
3	SCC Socket Reference Designator	7	Serial Number	11	J21
4	Screw Terminal Block	8	J24		

Figure 3-11. SC-2345 Configurable Connector (Side Cabled) Board Parts Locator Diagram

I/O Panelette Labels

Each SC-2345 configurable connector enclosure ships with a sheet of labels for you to apply to your I/O panelettes (see Figure 3-12). The label sheet has both preprinted and blank labels. You can customize the blank labels to suit your application. You can use two labels on single-width I/O panelettes and three or more labels on wider panelettes.



1 I/O Panelette	2 Label

Figure 3-12. Installing an I/O Panelette Label

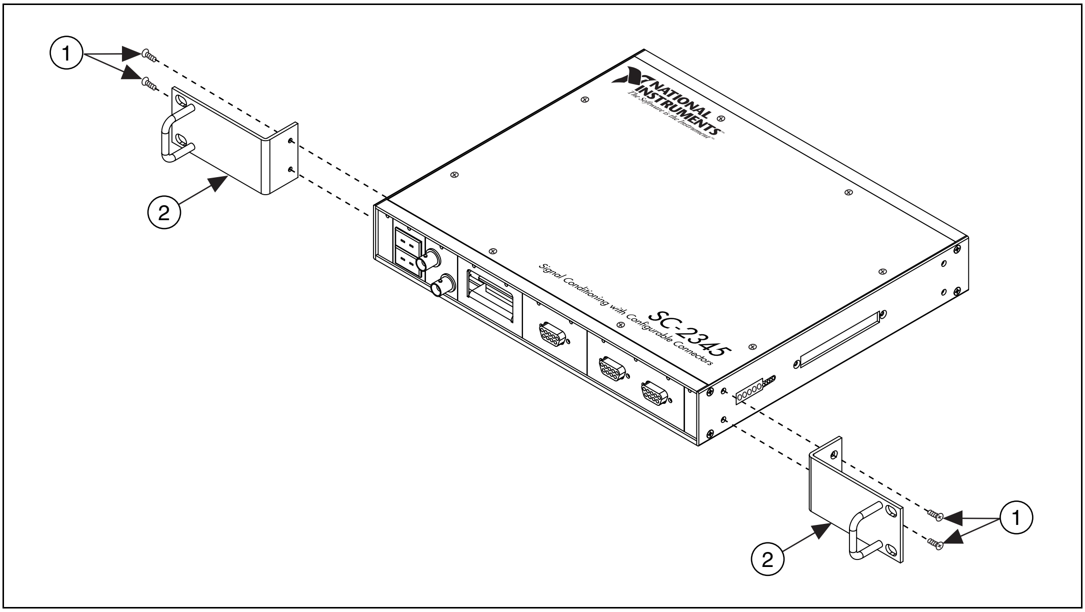
Mounting Options

To use your SC-2345 configurable connector enclosure in a standard 19 in. rack-mount configuration install the optional CA-1000 rack-mount kit. To use your SC-2345 configurable connector enclosure in a desktop stacking configuration install the optional CA-1000 stack-mount kit.

Refer to Figure 3-13 and use the following steps to install the CA-1000 rack-mount kit on your SC-2345 configurable connector enclosure:

1. Attach a rack-mount bracket to one end of the enclosure with two 4-40 × 1/4 in. screws from the rack-mount kit.
2. Attach a rack-mount bracket to the other end of the enclosure with two 4-40 × 1/4 in. screws from the rack-mount kit.

Note You must remove the rubber feet from the bottom of the SC-2345 enclosure for use in rack-mount applications.



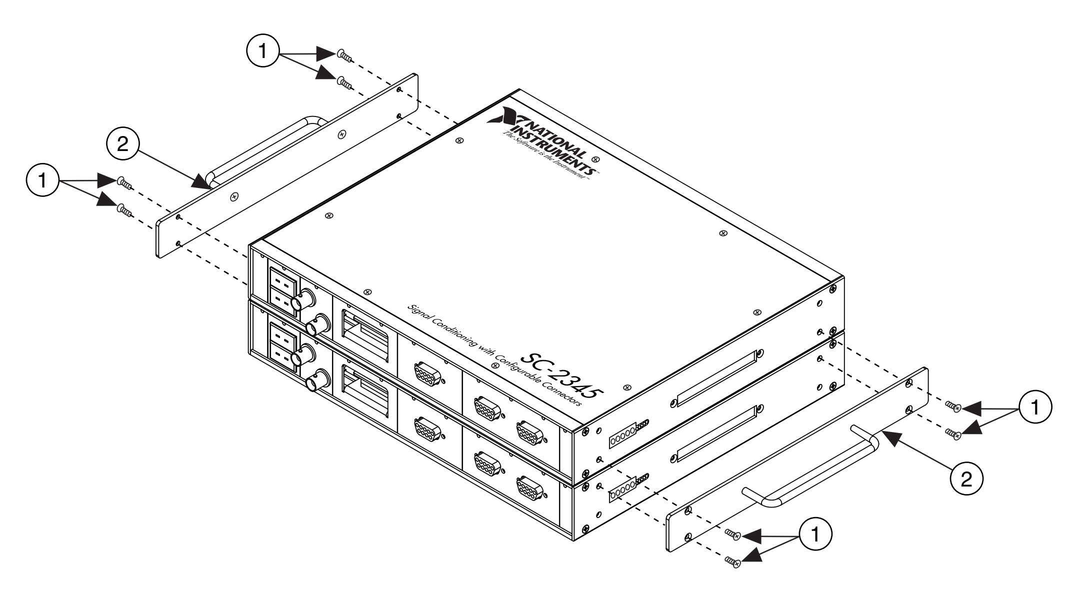
1 4-40 x 1/4 in. Screws	2 Rack-Mount Brackets

Figure 3-13. Rack-Mount Option

Refer to Figure 3-14 and use the following steps to install the CA-1000 stack-mount kit on your SC-2345 configurable connector enclosure:

1. Attach the stack-mount brackets to both ends of the lower enclosure with the 4-40 × 1/4 in. flathead screws from the stack-mount kit.
2. Place the upper enclosure on top of the lower enclosure.
3. Attach the stack-mount brackets to both ends of the upper enclosure with the 4-40 × 1/4 in. flathead screws from the stack-mount kit.

Note You must remove the rubber feet from all but the bottom enclosure before stacking the enclosures.



1 4-40 × 1/4 in. Screws	2 Stack-Mount Brackets

Figure 3-14. Stack-Mount Option

You can stack additional enclosures by using additional stack-mount kits. You can remove the stack-mount kit handles, if necessary, by removing the two screws that attach the handle.

Figures 3-15 and 3-16 show how to install analog input and DIO SCC modules into the SC-2345 configurable connector.

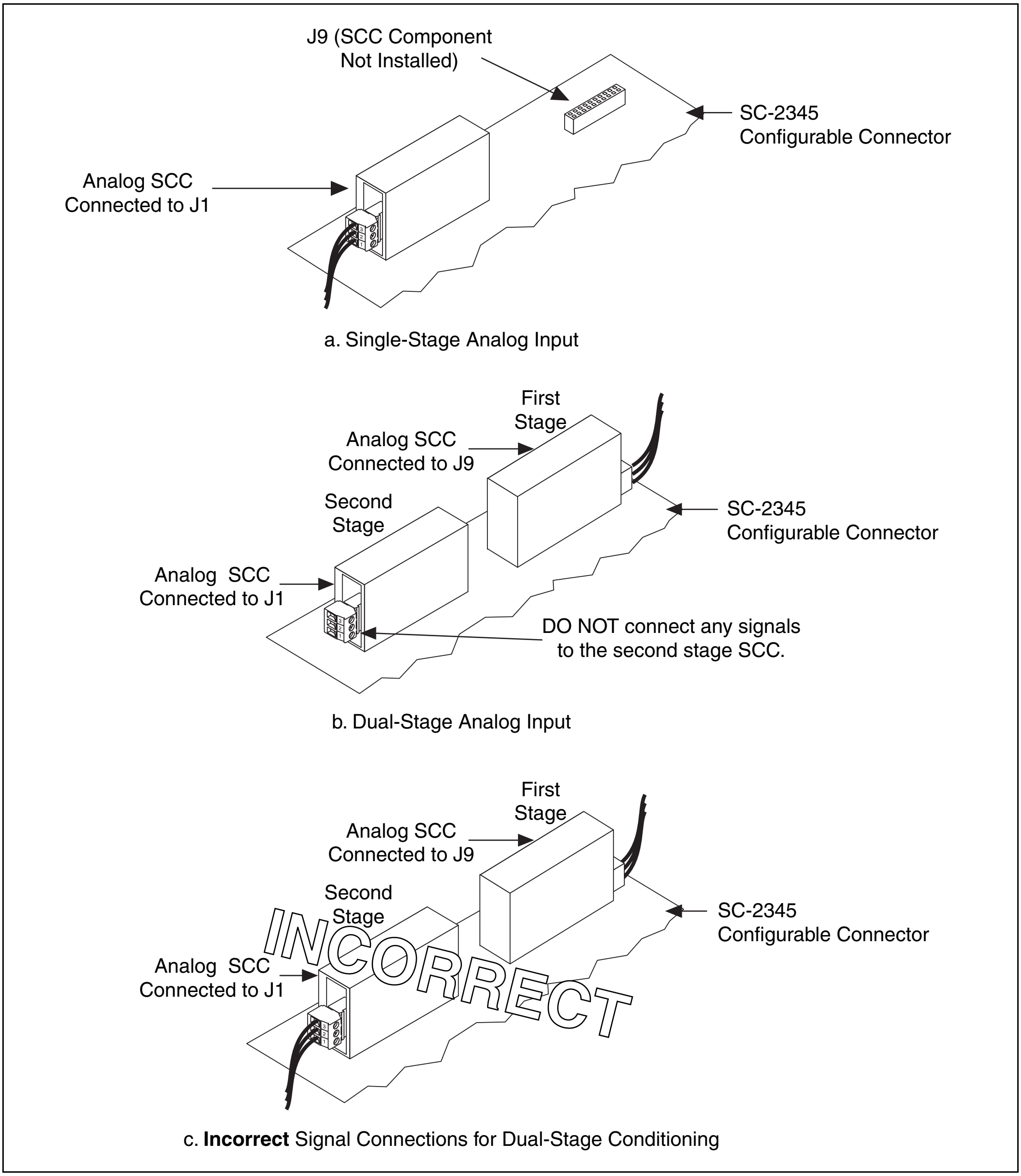
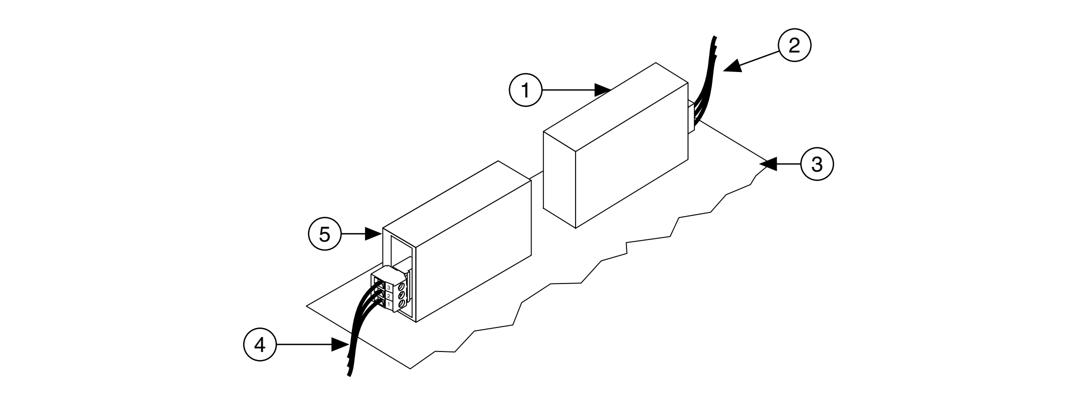


Figure 3-15. Single and Dual-Stage Analog Input SCC Configuration for SC-2345 Configurable Connector



1	Digital SCC Connected to J9	3	SC-2345 Configurable Connector	4	Inputs
2	Inputs			5	Analog SCC Connected to J1

Figure 3-16. Single-Stage Analog Input and DIO SCC Configuration for SC-2345 Configurable Connector

4

SCC Series Modules

This chapter describes signal conditioning modules for the SC-2345 carriers.

The SCC Series modules include the following:

- SCC-A10 voltage attenuator (buffered)
- SCC-AI isolated analog input
- SCC-CI20 current input (buffered)
- SCC-ICP integrated circuit piezoelectric input
- SCC-LP lowpass filter
- SCC-RTD01 resistance-temperature detector input
- SCC-SG strain-gauge
- SCC-TC thermocouple input
- SCC-FT01 feedthrough
- SCC-DI01 isolated digital input
- SCC-DO01 isolated digital output

See Appendix B, *SCC Feature Reference Table*, to calculate the power requirements for your SCC modules.

SCC-A10 Voltage Attenuator Module (Buffered)

The SCC-A10 voltage attenuator accepts up to two voltage sources at a maximum of 100 V, attenuates each source by a factor of 10, and provides a differential measurement of the source. A differential instrumentation amplifier buffers the input signals allowing maximum scan rates by the E Series device. The SCC-A10 contains circuitry capable of protecting E Series devices for input signals up to 250 $V_{rms.}$

A blue label stripe identifies the SCC-A10 as an analog input module. Figure 4-1 shows the icon that represents the SCC-A10.

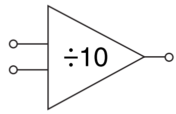


Figure 4-1. SCC-A10 Icon

You can plug the SCC-A10 into any analog input socket on the SC-2345, although the module cannot function as the second stage of a dual-stage configuration.

The SCC-A10 has two differential analog input channels that can measure signals of up to 100 V. Pins 1 and 2 form a differential channel that is routed to E Series device channel *X*+8, where *X*+8 is channel 8 through 15 depending on the socket where you plug the SCC-A10. Pins 3 and 4 form the second differential channel that is routed to E Series device channel *X*, where *X* is channel 0 through 7 depending on the socket where you plug the SCC-A10.

Your signal source can be floating or ground-referenced. Floating signal sources do not require bias resistors to ground with the SCC-A10. The SCC-A10 design does not require high-impedance bias resistors for floating sources. Figure 4-2 shows the SCC-A10 signal connections.

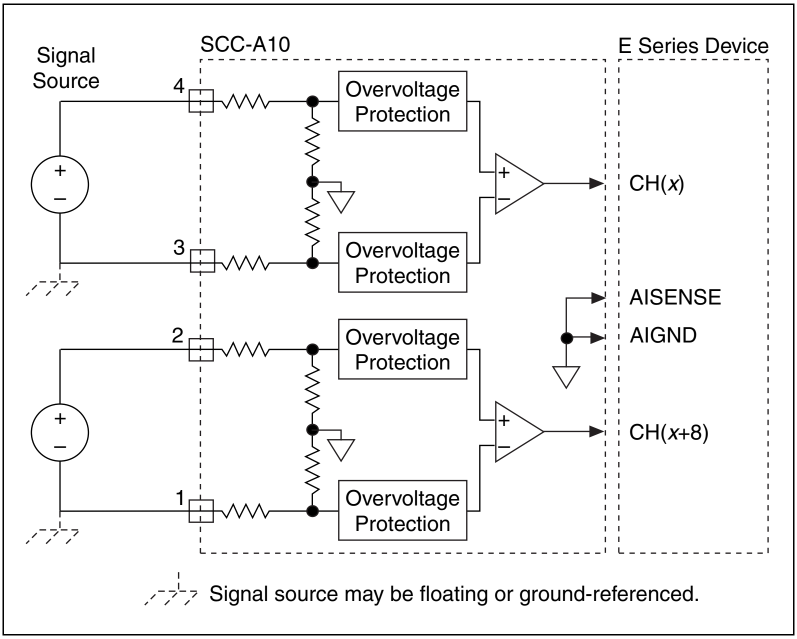


Figure 4-2. SCC-A10 Signal Connections

Measurement Scaling Considerations

In your software environment if you configured the SCC-A10 using Measurement & Automation Explorer and you are using NI-DAQ software calls, the voltage reading you get from the E Series DAQ device will account for the voltage scaling effect of the SCC-A10. Otherwise, since the voltage measurement from the E Series DAQ device is one-tenth of the voltage applied at the SCC-A10 input, you must multiply the voltage reading you got from the E Series DAQ device by 10 to get the correct input voltage.

SCC-AI Series Isolated Analog Input Modules

The SCC-AI*XX* isolated input modules fulfill two purposes. The first purpose is to convert a signal with high common-mode voltage into a single-ended signal referenced to the E Series device AI ground. After this conversion, you can extract the input signal from a high common-mode voltage before it is sampled by the E Series device. The second purpose of the SCC-AI*XX* isolated input modules is to amplify and filter the input signals, resulting in higher measurement resolution and accuracy. The gain and bandwidth for each module are given in Table 4-1.

Note The SCC-AI*XX* is safe for use with transients associated with local level main supplies of up to 300 V Installation Category (over-voltage category) II. Category II 300 V local level main supplies can see occasional transients of up to 1500 V. In compliance with IEC/EN 61010-1, UL 3111-1, and CSA/CAN C22.2 No. 1010.1 safety standards, all SCC modules are factory tested at 2300 V, input to output, to ensure that the safety insulation remains intact.

Table 4-1. SCC-AI*XX* Module Input/Output Range, Gain, and Bandwidth

Model	Input Range	Output Range	Gain	Bandwidth
SCC-AI01	±42 V	±8.4 V	0.2	10 kHz
SCC-AI02	±20 V	±10 V	0.5	10 kHz
SCC-AI03	±10 V	±10 V	1	10 kHz
SCC-AI04	±5 V	±10 V	2	10 kHz
SCC-AI05	±1 V	±10 V	10	10 kHz
SCC-AI06	±100 mV	±10 V	100	10 kHz
SCC-AI07	±50 mV	±10 V	200	10 kHz
SCC-AI13	±10 V	±10 V	1	4 Hz
SCC-AI14	±5 V	±10 V	2	4 Hz

A blue label stripe identifies the SCC-AI*XX* as an analog input module. Figure 4-3 shows the icon that represents the SCC-AI*XX* modules.

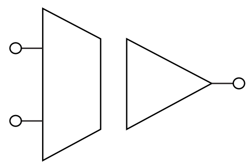


Figure 4-3. SCC-AI*XX* Icon

You can plug the SCC-AI*XX* into any analog input socket on the SC-2345, although the module cannot function as the second stage of a dual-stage configuration.

Each SCC-AIXX module has two isolated, single-ended analog input channels for measuring signals within the ranges given in Table 4-1.

Pins 1 and 2 form a channel that is routed to the E Series device channel *X*+8, where *X*+8 is channel 8 through 15 depending on the socket where you place the SCC-AI*XX*. Pins 3 and 4 form a channel that is routed to E Series device channel *X*, where *X* is 0 through 7 depending on the socket where you place the SCC-AI*XX*. These modules provide channel-to-ground isolation only. They do not provide channel-to-channel isolation. Since both channels must have the same reference voltage, pins 1 and 3 are internally connected together. Figure 4-4 shows the SCC-AI*XX* signal connections.

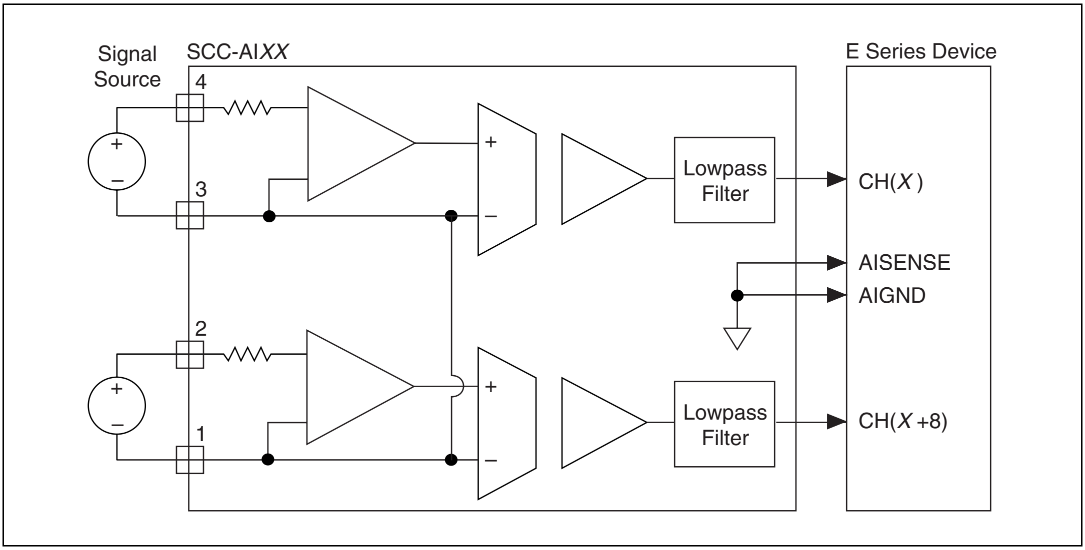


Figure 4-4. SCC-AI*XX* Signal Connections

The inputs are designed in a floating single-ended configuration. You can safely reference the measured voltage to a ground level with working common-mode voltage up to 300 V in a Category II installation. If a high common mode voltage is present, connect the negative input pins, pins 1 and 3, to this signal reference. If the measured signals are floating, connect the negative input pins, pins 1 and 3, to AISENSE on the SC-2345 terminal block with a 10 kΩ to 100 kΩ resistor, as shown in Figure 4-5. AISENSE is located on the SC-2345 terminal block, shown in Figures 3-5, 3-10, and 3-11. Figure 4-6 shows how to connect a ground referenced signal to the SCC-AI*XX*.

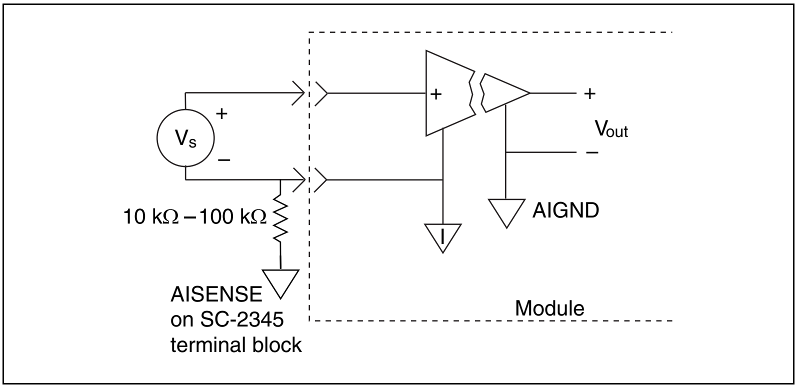


Figure 4-5. Floating Signal Connection for the SCC-AI*XX*

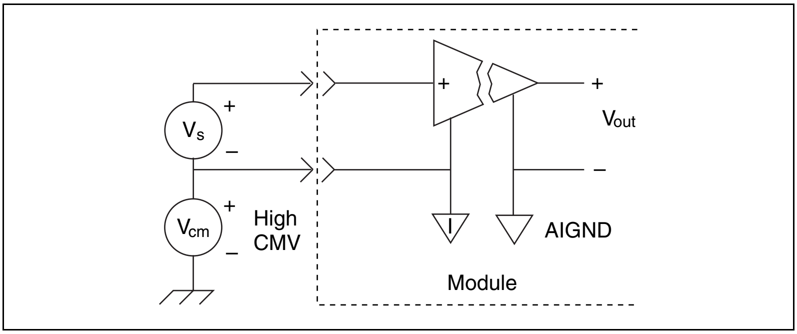


Figure 4-6. Ground-Referenced Signal Connection for the SCC-AI*XX* with High Common-Mode Voltage

The SCC-AI*XX* modules contain lowpass filter circuitry. The cutoff frequency is 10 kHz or 4 Hz, depending on the module. Refer to Table 4-1 for individual module gains and bandwidths.

Calibrating Gain and Offset Errors

The SCC-AI*XX* modules are calibrated at the factory before shipment. If you want to adjust the gain of the SCC-AI*XX* in your system using your E Series device, you need a voltage source capable of providing a DC voltage shown in Table 4-2 that is several times more accurate than the SCC itself.

Table 4-2. SCC-AI*XX* Input Voltage Requirements

Module	Input Voltage Required
SCC-AI01	40 V
SCC-AI02	16 V
SCC-AI03	8 V
SCC-AI04	4 V
SCC-AI05	800 mV
SCC-AI06	80 mV
SCC-AI07	40 mV
SCC-AI13	8 V
SCC-AI14	4 V

To adjust the gain of the SCC-AI*XX* use the following procedure:

1. Select the desired SCC-AI*XX* channel on the E Series device.
2. Set the gain on the E Series device so that the E Series input range is ±10 V.
3. Connect the voltage source to the screw terminals of your desired channel on the SCC-AI*XX*.
4. Apply the voltage given in Table 4-2 that corresponds to your SCC-AI*XX* module. For example, if you have an SCC-AI03, you must apply 8 VDC.
5. Using your software, have the E Series device read the desired channel on the SCC-AI*XX* and record the value.
6. Input 0 VDC to the SCC-AI*XX*.
7. Have the E Series device read that channel and record the value.
8. Subtract the values read (*first reading – second reading*).
9. Adjust the appropriate trimpot protruding through the top of the SCC-AI*XX*, labeled *Gain*.
10. Repeat steps 4 through 9 until the difference you got in step 8 equals the Input Voltage Required value shown in Table 4-2—8 V in this example using an SCC-AI03.

Note Turn the trimpot clockwise to increase the gain.

For example, assume that you have an SCC-AI03 module. You first connect 8 VDC to the input of CH(*X*). The E Series device reads 8.05 V as the SCC output. You then connect 0 VDC to the input of CH(*X*) and the E Series device reads –0.01 V as the SCC output. You subtract these readings, 8.05 – (–0.01) = 8.06 getting a difference of 8.06 V. Because this difference is not equal to 8 V, you must adjust the gain trimpot and repeat the procedure until the difference in outputs equals 8 V.

Note In this example there may be an offset voltage such that the final readings are 8.01 V and 0.01 V for a difference of 8 V. The Gain trimpot adjusted in step 9 of the above procedure only adjusts for gain errors and does not compensate for this offset voltage.

Use the following procedure to adjust the offset voltage of the SCC-AI*XX*:

1. Select the desired SCC-AI*XX* channel on the E Series device.
2. Set the gain on the E Series device so that the E Series input range is ±10 V.
3. Connect the screw terminals of your desired channel on the SCC-AI*XX* together.
4. Using your software, have the E Series device read the channel.
5. If the value read is not equal to 0.00 V, adjust the appropriate trimpot protruding through the top of the SCC-AI*XX*, labeled *Offset*. Turning the trimpot clockwise causes the offset to be increased.
6. Repeat steps 4 and 5 until the voltage read in step 4 equals 0.00 V.

Measurement Scaling Considerations

If you configured the SCC-AI*XX* using Measurement & Automation Explorer, the voltage reading you get from the E Series DAQ device accounts for the voltage scaling effect of the SCC-AI*XX* modules. Otherwise, since the voltage measurement from the E Series DAQ device is scaled by the gain given in Table 4-1, you must divide the voltage reading returned by the device by this gain to get the correct input voltage.

SCC-CI20 Current Input Module (Buffered)

The SCC-CI20 accepts up to two current sources at a maximum of 20 mA. The SCC-CI20 converts the current to voltage using a precision 249 Ω resistor and provides a differential measurement of the source. The E Series device measures voltage as a 0 to +5 V input signal. A differential instrumentation amplifier buffers the input signals allowing maximum scan rates by the E Series device.

A blue label stripe identifies the SCC-CI20 as an analog input module. Figure 4-7 shows the icon that represents the SCC-CI20. You can plug the SCC-CI20 into any analog input socket.

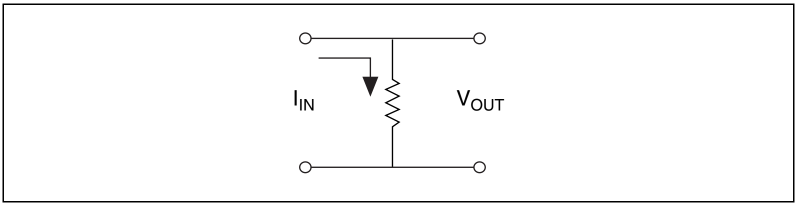


Figure 4-7. SCC-CI20 Icon

The SCC-CI20 provides two differential analog input channels for 0 to 20 mA signals. Pins 1 and 2 form a differential channel that is routed to E Series device channel *X*+8, where *X*+8 is channel 8 through 15 depending on the socket where you plug the SCC-CI20. Pins 3 and 4 form the second differential channel that is routed to E Series channel *X*, where *X* is channel 0 through 7 depending on the socket where you plug the SCC-CI20. Figure 4-8 shows the SCC-CI20 signal connections.

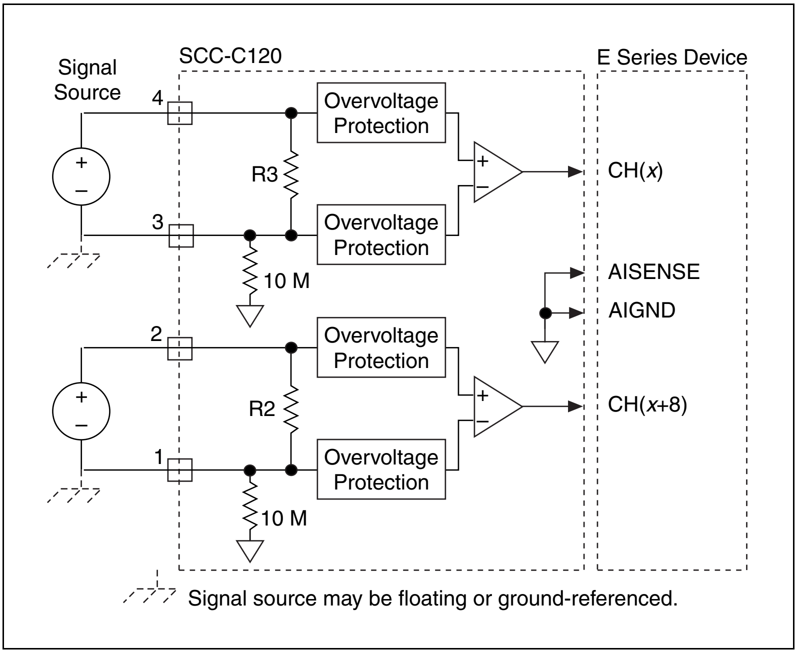


Figure 4-8. SCC-CI20 Signal Connection

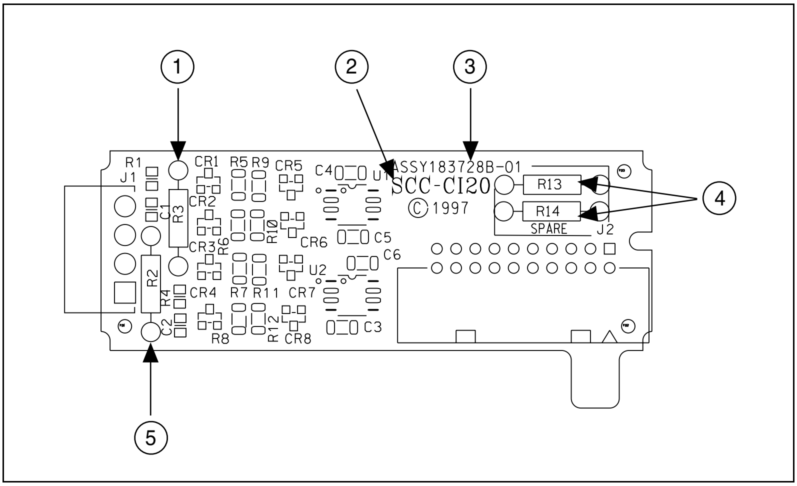
Input Resistor Replacement

Your signal source can be floating or ground-referenced. Floating signal sources do not require bias resistors to ground with the SCC-CI20. The SCC-CI20 has high-impedance bias resistors typically required for floating sources.

Incorrect connections can damage the input resistors. Spare 249 Ω resistors are available inside the SCC-CI20. To open the SCC-CI20:

1. Remove the screw from the back (wide unlabeled side).
2. Turn the front (wide labeled side) toward you.
3. Place the screw terminal receptacle to the left.
4. Slide the top cover to the right.
5. Lift off the cover.

The locations of the spare resistors are illustrated in Figure 4-9. Resistor 2 (R2) and resistor 3 (R3) are socketed for quick and easy replacement. Replace R2 and R3 with the spares when needed.



1	R3	3	Assembly Number	5	R2
2	Product Name	4	Spare Resistors		

Figure 4-9. SCC-CI20 Parts Locator Diagram

Measurement Conversion Considerations

In your software environment if you have configured the SCC-CI20 using Measurement & Automation Explorer and you are using NI-DAQ software calls, the reading you get from the E Series device accounts for the voltage to current conversion and returns milliamps not volts. Otherwise the measurement from the E Series device is a unit of volts; you must convert your voltage measurement to current measurement. To make this conversion, use the following formula:

$$I = \frac{V}{0.249}$$

where I is milliamps and V is volts.

SCC-ICP01 Integrated Circuit Piezoelectric Input Module

The SCC-ICP01 input module accepts an ICP input signal of analog bandwidth that is less than 5 kHz (recommended). The signal passes through a 0.8 Hz highpass filter, is amplified, and then passes through a 19 kHz lowpass Bessel filter. The output is buffered to allow maximum scan rates. This module has a fixed gain of 2, therefore, the maximum input is ±5 V.

The SCC-ICP01 provides a 4 mA current source for ICP excitation.

A blue stripe identifies the SCC-ICP01 as an analog input module. Figure 4-10 shows the icon that represents the SCC-ICP01.

ICP®

Figure 4-10. SCC-ICP01 Icon

Signal Connections

The SCC-ICP01 provides one differential analog input channel for measuring the voltage across the ICP. Pins 1 and 2 form a differential channel that is routed to E Series channel *X*, where *X* is channel 0 through 7 depending on the socket into which you plug the SCC-ICP01. Pins 3 and 4 are used for the constant-current excitation source of 4 mA. Figure 4-11 shows the signal connections.

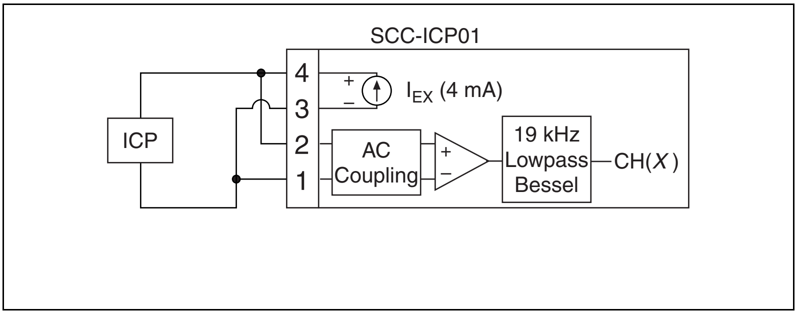


Figure 4-11. SCC-ICP01 Signal Connections

Notes Your signal source can be floating or ground referenced. The SCC-ICP01 has high impedance bias resistors typically required for floating sources. External bias resistors connected to ground are not required.

You can plug the SCC-ICP01 into any analog input socket on the SC-2345. Due to the unique front end circuit required for ICP sensors, this module cannot function as the second stage of a dual-stage configuration.

For floating signal sources in high noise environments, connecting the negative terminal of the signal source to the AIGND terminal on the SC-2345 screw terminal block reduces common-mode noise.

Measurement Conversion Considerations

If you have configured the SCC-ICP01 using Measurement & Automation Explorer and you are using NI-DAQ driver software, the reading you get from the E Series DAQ device is properly scaled. Otherwise you must scale and convert your readings as described below:

1. Measure the ICP voltage.
   a. Read the ICP channel on the E Series DAQ device $V_{ESERIES}$ (CH*X*).
   b. Calculate the ICP voltage using this formula:

$$V_{ICP} = V_{ESERIES}/2$$

   where

   V_{ICP} is the ICP voltage.

   $V_{ESERIES}$ is the E Series DAQ device voltage.

Note This step provides proper scaling for the ICP amplifier in the SCC-ICP01.

2. Use scaling constants obtained from your sensor data sheet to convert the ICP voltage to the desired unit such as Newtons, m/s^2, or g.

System Accuracy

The system accuracy is determined by the combined accuracy of the SCC module and the E Series device. SCC modules that are under factory calibration condition have the following system accuracy:

$$System\ Accuracy = (GE_E \times Reading) + E_E + OE_S$$

where

GE_E is gain error as a percent of the reading of the E Series DAQ device.

Reading is the measured voltage.

E_E is the offset voltage error in volts of the E Series DAQ device.

OE_S is the offset error in mV of the SCC module.

SCC-LP Lowpass Filter Module

The SCC-LP series components are fourth-order Butterworth filter components that accept signals within a ±10 V range. The input signals pass through a differential amplifier providing a differential measurement, attenuated by a factor of two. The output of the amplifier passes through a fourth-order Butterworth filter circuit that is buffered to allow maximum scan rates.

The SCC-LP series consists of the following modules:

- SCC-LP01—cutoff frequency, 25 Hz
- SCC-LP02—cutoff frequency, 50 Hz
- SCC-LP03—cutoff frequency, 150 Hz
- SCC-LP04—cutoff frequency, 1 kHz

A blue label stripe identifies the SCC-LP as an analog input component. Figure 4-12 shows the icon that represents the SCC-LP. You can plug the SCC-LP into any analog input socket.

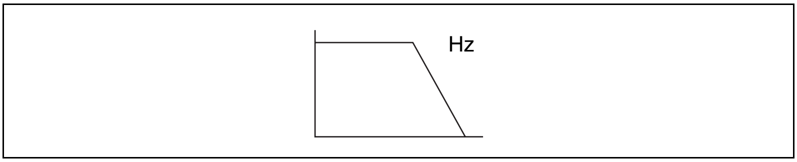


Figure 4-12. SCC-LP Icon

SCC-LP Performance

The filter used in the SCC-LP series components is a Butterworth filter, and is characterized by maximal flatness in the passband with very sharp monotonic rolloff. It has a nonlinear phase response, the delay is not constant, and the step response exhibits a moderate amount of overshoot (ringing). These characteristics present no problems for amplitude-based applications.

The Butterworth filter is a good general-purpose filter. Figures 4-13 through 4-16 show the typical response curve for each SCC-LP.

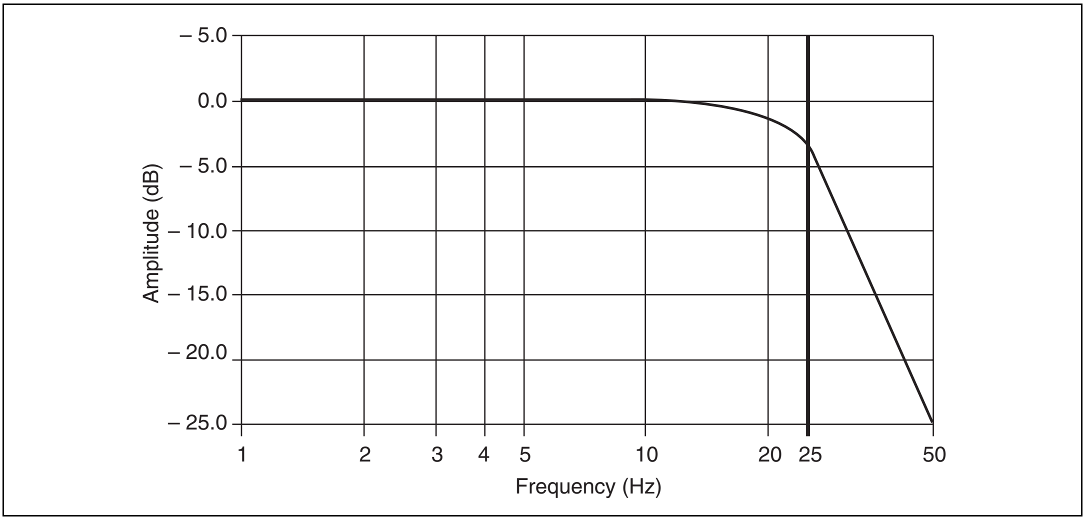


Figure 4-13. Typical Response Curve SCC-LP01

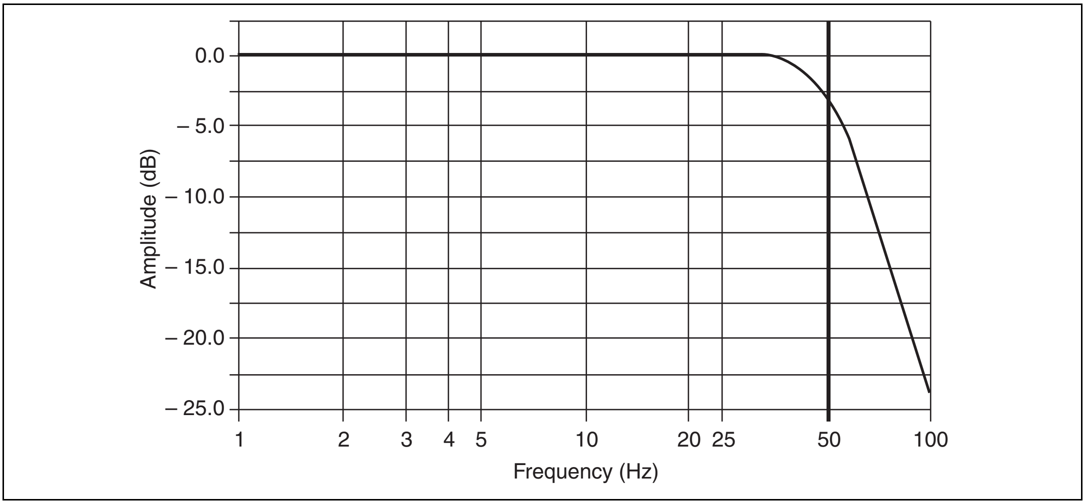


Figure 4-14. Typical Response Curve SCC-LP02

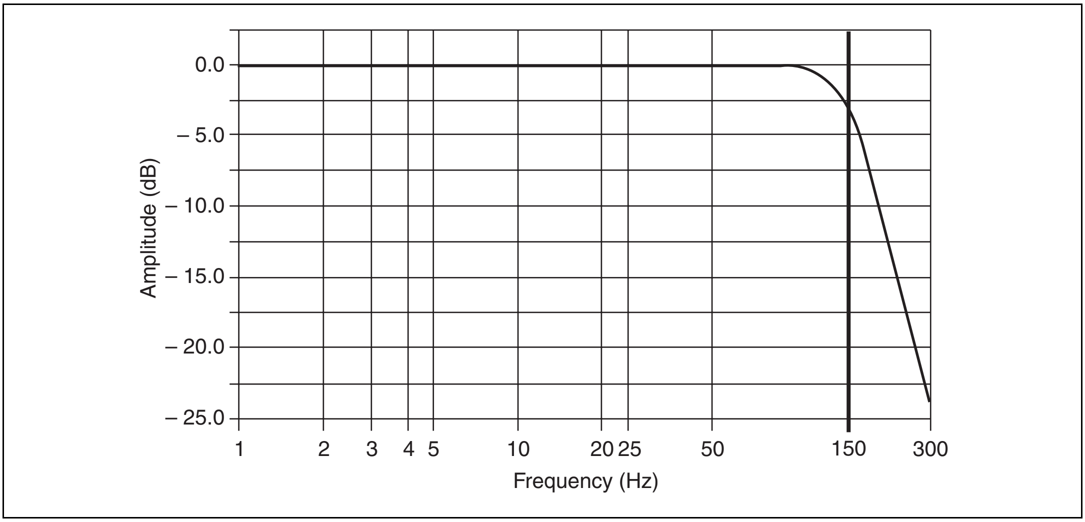


Figure 4-15. Typical Response Curve SCC-LP03

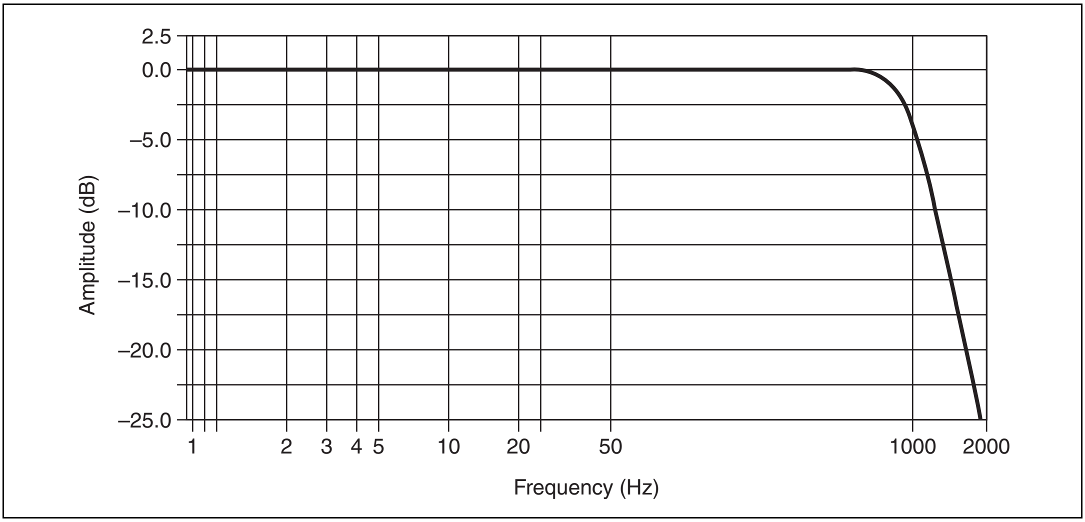


Figure 4-16. Typical Response Curve SCC-LP04

Figure 4-17 shows the theoretical transfer characteristics of the SCC-LP. The graphs show plots with the frequency axis normalized to the cutoff frequency, where the cutoff frequency has the value of 1.

Figure 4-17a shows that the SCC-LP provides 80 dB attenuation above ten times the cutoff frequency. Figure 4-17b shows the group delay of the SCC-LP, which ideally is constant. Figure 4-17c shows the SCC-LP response to a step input. As shown, the peak voltage of the output is greater than the peak voltage of the input. When you choose a gain setting on the E Series device, you must consider the added effects of ringing if you expect step inputs.

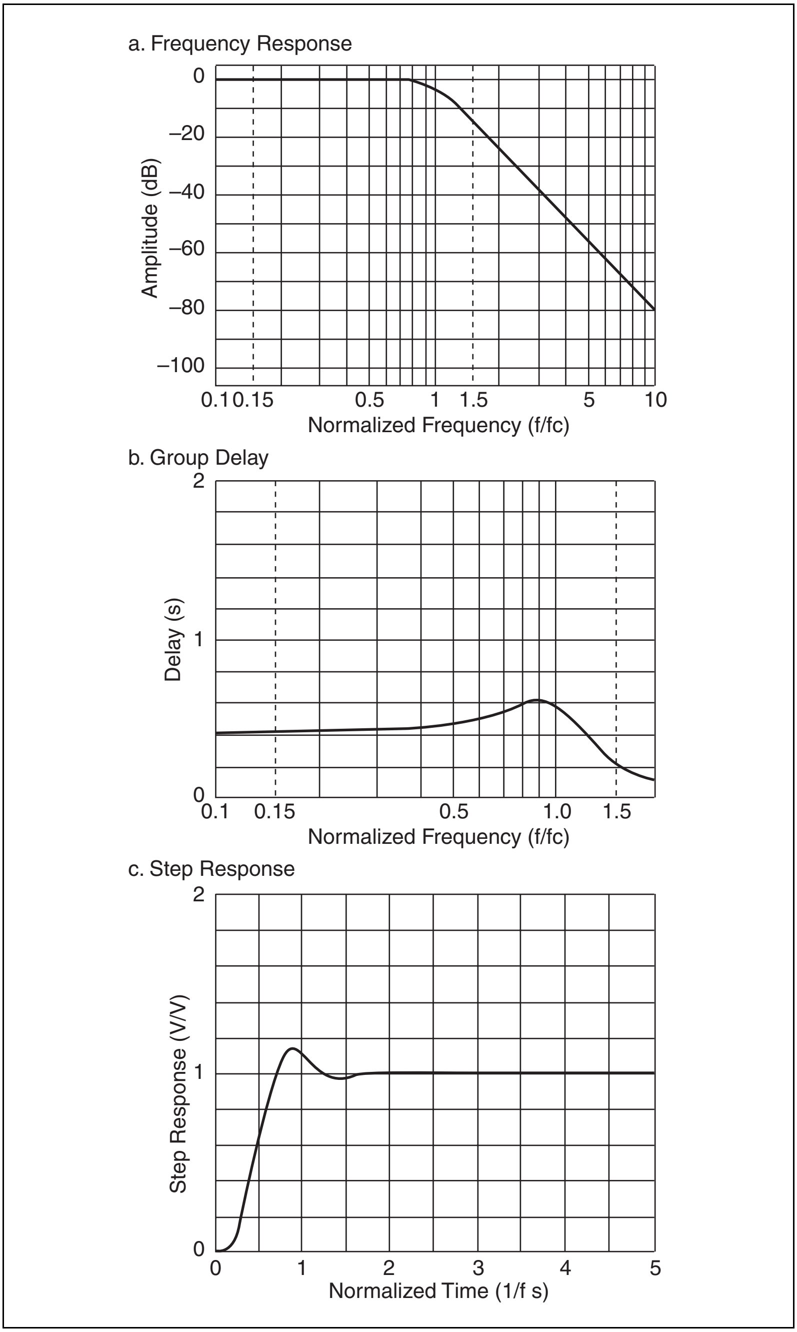


Figure 4-17. Theoretical Transfer Characteristics

Using the SCC-LP as an Antialiasing Filter

Aliasing, a phenomenon of sampled data systems, causes high-frequency signal components to take on the identity of a low-frequency signal. Figure 4-18 shows an example of aliasing.

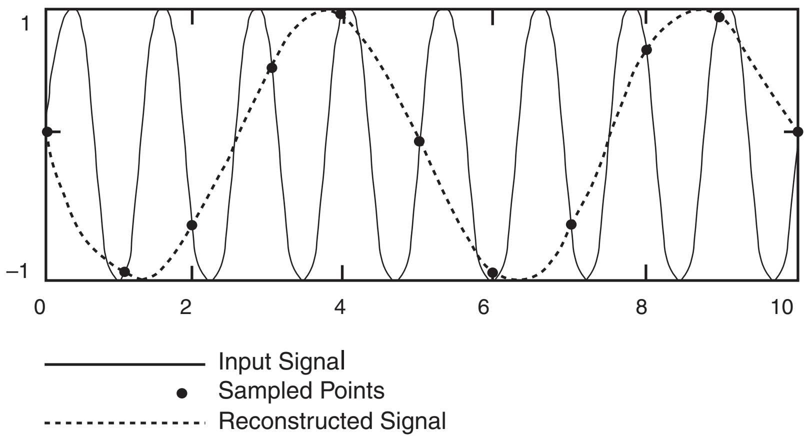


Figure 4-18. Aliasing of an Input Signal with a Frequency of 0.8 Times the Sample Rate

The solid line depicts a high-frequency signal being sampled at the indicated points. However, when these points are connected to reconstruct the waveform, as shown by the dotted line, the signal appears to have a lower frequency. Any signal with a frequency greater than one-half of the sample rate will be aliased and incorrectly analyzed as having a frequency below one-half of the sampling rate. This limiting frequency of one-half the sample rate is known as the *Nyquist frequency*.

To prevent aliasing, you must remove all of the signal components with frequencies greater than the Nyquist frequency from an input signal *before* you sample it. When you sample the data and aliasing occurs, it is impossible to accurately reconstruct the original signal.

The SCC-LP removes these high-frequency signals before they reach the E Series device and cause aliasing. Because the SCC-LP stopband begins at ten times the cutoff frequency (for an attenuation of 80 dB), the Nyquist frequency should be at least ten times the cutoff frequency. Thus, the rate at which the E Series device samples a channel should be at least 20 times the filter cutoff frequency.

For example, if you use the SCC-LP01, which has a cutoff frequency of 25 Hz, you can calculate the *minimum* scan rate used by the E Series device to prevent aliasing— 25 Hz × 20 = 500 samples per second per channel.

Signal Connections

The SCC-LP provides two differential analog input channels for measuring signals within a specific SCC-LP passband. Pins 1 and 2 form a differential channel that routes to E Series device channel *X*+8, where *X*+8 is channel 8 through 15 depending on the socket where you plug the SCC-LP. Pins 3 and 4 form the second differential channel that routes to E Series device channel *X*, where *X* is channel 0 through 7 depending on the socket where you plug the SCC-LP.

Your signal source can be floating or ground-referenced. The SCC-LP has high-impedance bias resistors typically required for floating sources. Therefore when connecting floating signal sources, external bias resistors connected to ground are not required.

Note For floating signal sources in high noise environments, connecting the negative terminal of the signal source to the AIGND terminal on the SC-2345 screw terminal block reduces common-mode noise.

Figure 4-19 shows the SCC-LP signal connections.

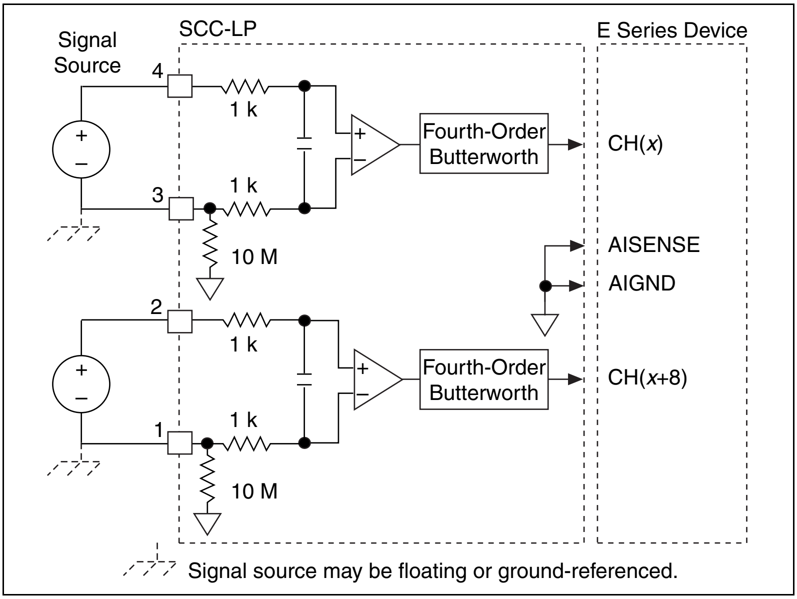


Figure 4-19. SCC-LP Signal Connection

Calibrating Gain Errors

The SCC-LP is calibrated at the factory before shipment. If you want to calibrate the SCC-LP in your system using your E Series device, you need a voltage source capable of providing a DC voltage up to ±10 V that is several times more accurate than the SCC itself.

To calibrate the SCC-LP, use the following procedure:

1. Select the desired SCC-LP channel on the E Series device.
2. Set the gain on the E Series device so that the E Series input range is ±5 V.
3. Connect the voltage source to the screw terminals of your desired channel on the SCC-LP.
4. Input 9 VDC to the SCC-LP.
5. Using your software, have the E Series device read your desired channel on the SCC-LP and record the value.
6. Input 0 VDC to the SCC-LP.
7. Have the E Series device read that channel and record the value.
8. Subtract the values read (*first reading – second reading*).
9. Adjust the appropriate trimpot protruding through the top of the SCC and repeat steps 4 through 8 until the difference you got in step 8 equals 9 V.

For example you connect 9 VDC to the input of CH(*X*) and the E Series device reads 9.05 V as the SCC output, then you connect 0 VDC to the input of CH(*X*) and the E Series device reads –0.01 V as the SCC output. Now you subtract the SCC outputs (9.05 – (–0.01) = 9.06) to get a difference of 9.06 V. Because the difference is not equal to 9 V, you adjust the trimpot until the difference in outputs equals 9 V.

Note In this example there may be an offset voltage such that the final voltages are 9.01 V and 0.01 V for a difference of 9 V. The SCC-LP trimpot adjusted in step 9 only adjusts for gain errors and does not compensate for this offset voltage.

System Accuracy

The system accuracy is determined by the combined accuracy of the SCC module and the E Series device.

SCC modules that are under factory calibration condition have the following system accuracy specification:

$$System\ Accuracy\ =\ (GE_E \times Reading) + E_E + OE_S$$

where

GE_E is gain error as a percent of the reading of the E Series device.

Reading is the measured voltage.

E_E is the constant voltage error in volts of the E Series device.

OE_S is the offset error in mV of the SCC module.

For example, the absolute accuracy specification of the AT-MIO-16E-2 using a ±5 V range and a one year interval specification is 0.0564% ±6.380 mV.

If you are using an SCC-LP filter module with an offset error equal to ±10 mV, the accuracy of the combined system is as follows:

$$System\ Accuracy = (0.0314\% \times Reading) + (\pm 3.198\text{ mV}) + (\pm 10\text{ mV})$$

Measurement Scaling Considerations

In your software environment if you configured the SCC-LP using Measurement & Automation Explorer and you are using NI-DAQ software calls, the voltage reading you get from the E Series device will account for the voltage scaling effect of the SCC-LP. Otherwise, since the voltage measurement from the E Series device is one-half of the voltage applied at the SCC-LP input, you must multiply the voltage reading you get from the E Series device by two to get the correct input voltage.

SCC-RTD01 Resistance-Temperature Detector Input Module

The SCC-RTD01 resistance-temperature detector module accepts up to two RTD input signals from 2-, 3-, or 4-wire RTDs of the following types:

- Pt100 (–100 to +850 °C), α = 0.00385 or 0.00392
- Ni120 (–80 to +320 °C)
- Cu10 (0 to 260 °C)

The RTDs are excited by a 1 mA precision current source provided on the SCC-RTD01.

The RTD inputs are filtered and passed into a differential amplifier with a gain of 25. The output of the amplifier passes through a 3-pole Sallen and Key 30 Hz filter and is buffered to allow maximum scan rates. Due to the fixed gain of 25, the maximum input voltage is 400 mV.

A blue stripe identifies the SCC-RTD01 as an analog-input module. Figure 4-10 shows the icon that represents the SCC-RTD01.

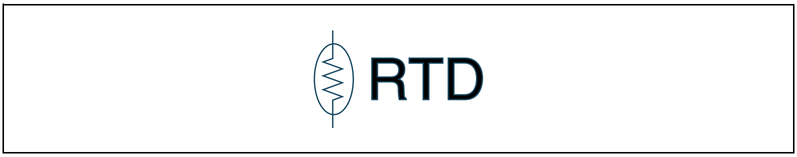


Figure 4-20. SCC-RTD01 Icon

Signal Connections

The SCC-RTD01 provides two differential analog input channels for measuring the voltage across the RTD. Pins 1 and 2 form a differential channel that is routed to E Series channel *X*+8, where *X*+8 is channel 8 through 15 depending on into which socket you plug the SCC-RTD01. Pins 3 and 4 form the second differential channel that is routed to E Series channel *X*, where *X* is channel 0 through 7, depending on the socket selected. Pins 5 and 6 provide connection to the constant-current excitation source of 1 mA.

Notes Your RTD can be non-referenced (floating) or ground referenced. The SCC-RTD01 has high-impedance bias resistors typically required for floating signal sources. External bias resistors connected to ground are not required.

You can plug the SCC-RTD01 into any analog input socket on the SC-2345. Due to the unique front end circuit required for RTD sensors, this module cannot function as the second stage of a dual-stage configuration.

For floating signal sources in high noise environments, connecting the negative terminal of the signal source to the AIGND terminal on the SC-2345 screw terminal block reduces common-mode noise.

You can connect one or two RTDs to the SCC-RTD01 in 4-, 3-, and 2-wire configurations. Figure 4-21 contains wiring diagrams for connecting one 2-, 3-, or 4-wire RTD to the SCC-RTD01.

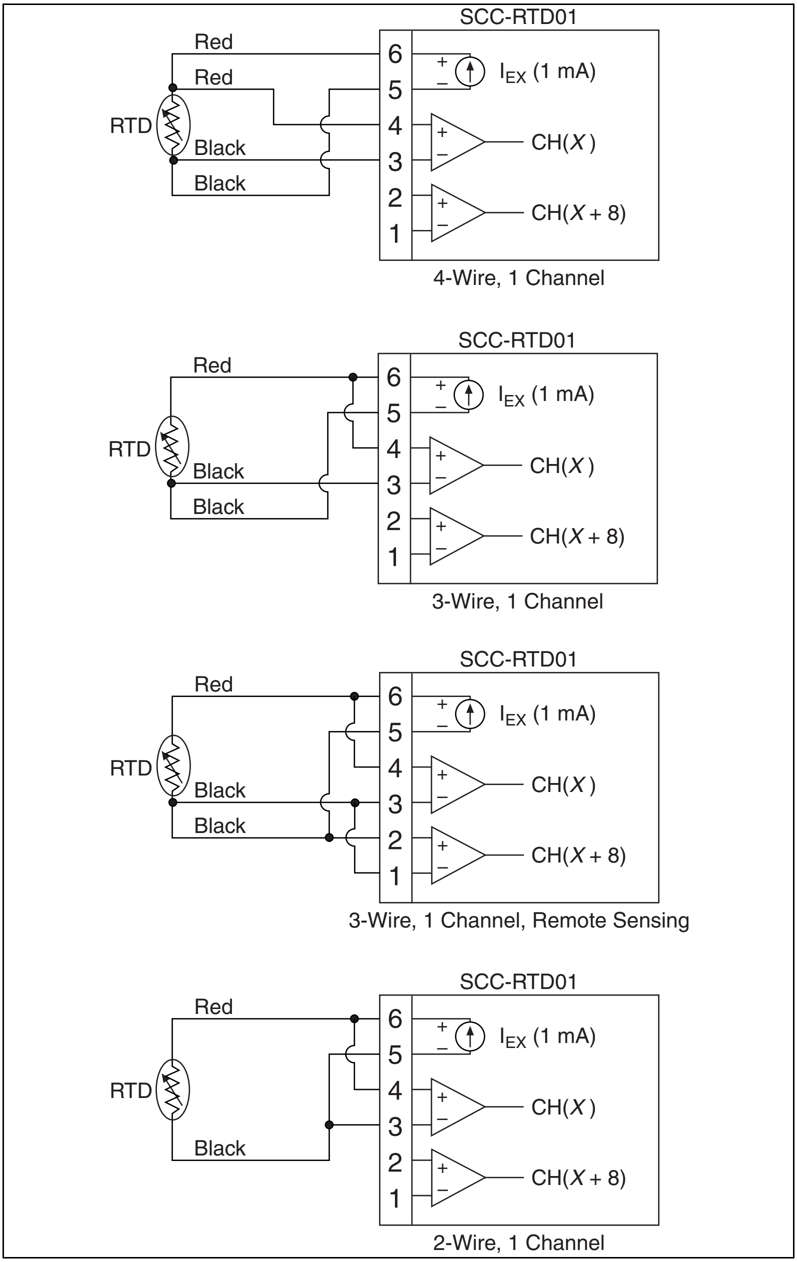


Figure 4-21. SCC-RTD01 Single-Channel Wiring Diagrams

Figure 4-22 contains wiring diagrams for connecting two 2-, 3-, or 4-wire RTDs, to the SCC-RTD01.

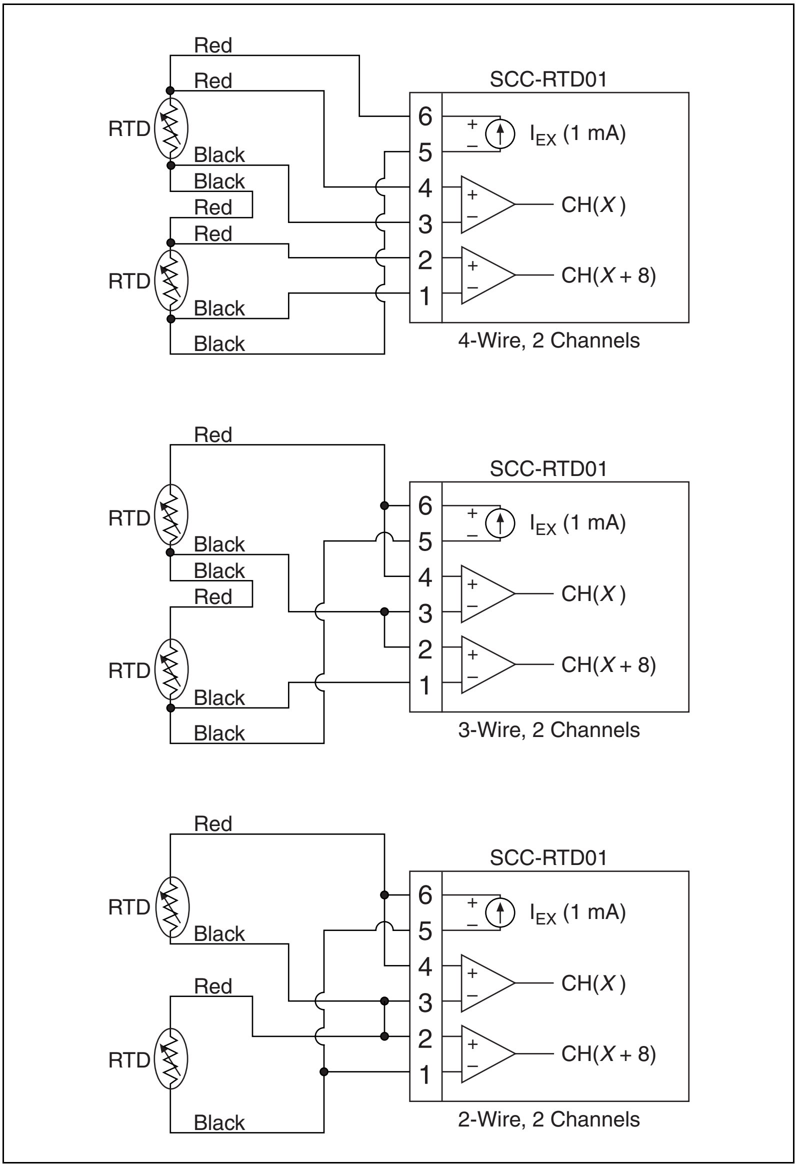


Figure 4-22. SCC-RTD01 Two-Channel Wiring Diagrams

Note 4-wire transducer connections produce more accurate measurements than either 2- or 3-wire connections, which introduce errors caused by lead resistance.

Measurement Conversion Considerations

The reading you get from the E Series DAQ device has already been properly scaled to temperature if you have configured the SCC-RTD01 using Measurement & Automation Explorer and you are using NI-DAQ driver software. Otherwise, you must scale your readings as described in step 1 and convert your voltage measurement to temperature as described in step 2:

1. Measure the RTD voltage.
   a. Read the RTD channel on the E Series DAQ device $V_{ESERIES}[CH(X)]$.
   b. Calculate the RTD voltage using the following formula:

   $$V_{RTD} = V_{ESERIES}/25$$

   where

   V_{RTD} is the RTD voltage.

   $V_{ESERIES}$ is the E Series DAQ device voltage.

   This step provides proper scaling for the RTD amplifier in the SCC-RTD01.
2. Convert the RTD voltage to temperature using polynomial expressions or a conversion table.

Note National Instruments programming environments include RTD conversion utilities that implement the voltage-to-temperature conversions required in step 2. Refer to your software documentation for more information on these utilities.

Although the RTD resistance versus temperature curve is relatively linear, accurately converting resistance to temperature requires curve fitting. The Callendar-Van Dusen equation is commonly used to approximate the RTD curve:

$$R_t = R_0[1 + \mathrm{A}t + \mathrm{B}t + \mathrm{C}(t - 100)^3]$$

where

R_t is the resistance of the RTD at temperature = t.

R_o is the resistance of the RTD at 0 °C.

A, B, and C are the Callendar-Van Dusen coefficients shown in Table 4-3.

t is the temperature in °C.

For temperatures above 0 °C, the C coefficient equals 0. Therefore, for temperatures above 0 °C, this equation reduces to a quadratic. If you pass a known current, I_{EX}, through the RTD and measure the voltage developed across the RTD, V_0, you can solve for t using the following formula:

$$t = \frac{2(V_0 - I_{EX}R_0)}{I_{EX}R_0[A + \sqrt{A^2 + (4B(V_0 - I_{EX}R_0))/(I_{EX}R_0)}]}$$

where

V_0 is the measured RTD voltage.

I_{EX} is the excitation current.

Most platinum RTD curves conform to one of the following three standardized curves:

- DIN 43760 standard.
- US Industrial or American standard.
- International Temperature Scale (used with wire-wound RTDs).

The Callendar-Van Dusen coefficients for each of these standard platinum RTD curves are listed in Table 4-3.

Table 4-3. Callendar-Van Dusen Coefficients for Platinum RTDs

Standard	Temperature Coefficient	A	B	C
DIN 43760	0.003850	3.9080×10^{-3}	-5.8019×10^{-7}	-4.2735×10^{-12}
American	0.003911	3.9692×10^{-3}	-5.8495×10^{-7}	-4.3235×10^{-12}
ITS-90	0.003926	3.9848×10^{-3}	-5.870×10^{-7}	-4.0000×10^{-12}

SCC-SG Series Strain-Gauge Modules

The SCC-SG series components are strain-gauge modules designed for full-bridge, half-bridge, 120 Ω quarter-bridge and 350 Ω quarter-bridge strain-gauge measurements. The SCC-SG family consists of two groups—the SCC-SG0*X* strain-gauge input series modules and the SCC-SG11 shunt calibration module. A blue label stripe identifies the SCC-SG family as analog input components.

The SCC-SG0*X* strain-gauge series consists of the SCC-SG01, SCC-SG02, SCC-SG03, and SCC-SG04. Each module consists of two strain-gauge input channels, offset-nulling circuitry for each channel, and a 2.5 V excitation circuit. Each input channel includes an instrumentation amplifier with differential inputs and a fixed gain of 100. The output of each amplifier is filtered and buffered to prevent settling time delays. The SCC-SG01 works with 120 Ω quarter-bridge setups. The SCC-SG02 works with 350 Ω quarter-bridge setups. The SCC-SG03 works with half-bridge setups. The SCC-SG04 works with full-bridge setups.

The SCC-SG11 is a shunt calibration module. It contains two shunt calibration circuits you connect across your bridge setups where you want to perform shunt calibration. The circuits are controlled by an E Series digital output channel DIO(*X*).

Strain Gauge Signal Connections

Each SCC-SG0*X* provides two differential analog input channels for measuring strain. The input pins to the SCC-SG0*X* differ for each version. Pin 4 is part of a differential channel that routes to E Series device channel *X*+8, where *X*+8 is channel 8 through 15 depending on the socket where you plug the SCC-SG0*X*. Pin 6 is part of a differential channel that routes to E Series device channel *X*, where *X* is channel 0 through 7 depending on the socket where you plug the SCC-SG0*X*.

SCC-SG01 and SCC-SG02 Quarter-Bridge Connection

In this configuration, you use only one strain gauge per channel. The internal half-bridge completion reference as well as a quarter-bridge completion resistor provides bridge completion. Figure 4-23 shows the icon that represents the SCC-SG01, and Figure 4-24 shows the icon that represents the SCC-SG02.

Figure 4-23. SCC-SG01 Icon

Figure 4-24. SCC-SG02 Icon

The quarter-bridge completion resistor should be equal in value to the external strain-gauge element. The SCC-SG01 contains a 120 Ω quarter-bridge completion resistor per channel. The SCC-SG02 contains a 350 Ω quarter-bridge completion resistor per channel. One quarter-bridge completion resistor is internally connected in series between R(*X*) and V_{ex-}. The other is between R(*X*+8) and V_{ex-}. Three lead wires connect your quarter-bridge strain gauge to screw terminals V_{ex+}, CH(*X*)+, and R(*X*). Of the two wires sharing the same end of the strain gauge, connect one to the CH(*X*)+ screw terminal and the other to the R(*X*) screw terminal. Connect the single wire end to the V_{ex+} screw terminal. Figure 4-25 shows this configuration using CH(*X*) versus CH(*X*+8).

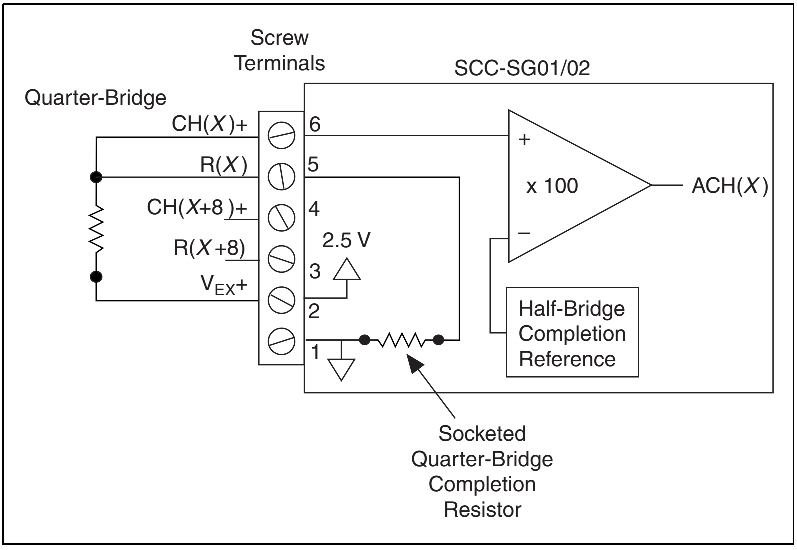


Figure 4-25. SCC-SG01/02 Quarter-Bridge Connection

SCC-SG03 Half-Bridge Connection

In this configuration, you use only two strain gauges per channel. A half-bridge completion reference internal to the SCC-SG03 provides bridge completion. Figure 4-26 shows the icon that represents the SCC-SG03.

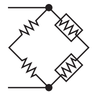


Figure 4-26. SCC-SG03 Icon

Three lead wires connect the half-bridge to screw terminals V_{ex+}, V_{ex-}, and CH(*X*)+. The pair of wires connected to V_{ex+} and V_{ex-} provide excitation voltage to the bridge and the other wire connected to CH(*X*)+ senses the output voltage of the half-bridge with respect to the internal half-bridge completion reference. Figure 4-27 shows this configuration using CH(*X*) versus CH(*X*+8).

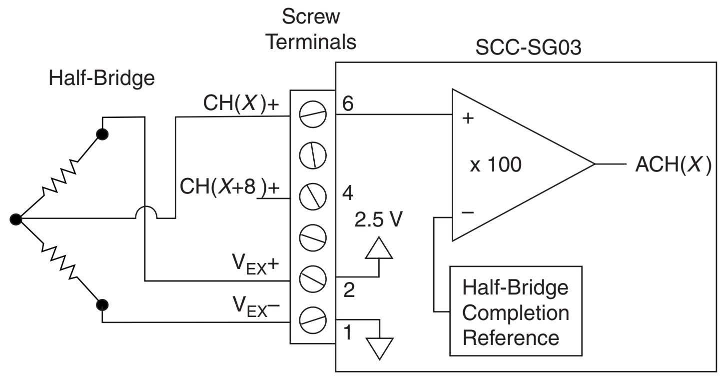


Figure 4-27. SCC-SG03 Half-Bridge Connection

SCC-SG04 Full-Bridge Connection

In this configuration, all four elements of the bridge are external to the SCC-SG04. Figure 4-28 shows the icon that represents the SCC-SG04.

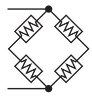


Figure 4-28. SCC-SG04 Icon

Four lead wires connect the full-bridge to screw terminals V_{ex+}, V_{ex-}, CH(*X*)+, and CH(*X*)–. The pair of wires connected to V_{ex+} and V_{ex-} provides excitation voltage to the bridge and the other pair connected to CH(*X*)+ and CH(*X*)– senses the output voltage of the bridge.

Figure 4-29 shows the SCC-SG04 configuration using CH(*X*) versus CH(*X*+8).

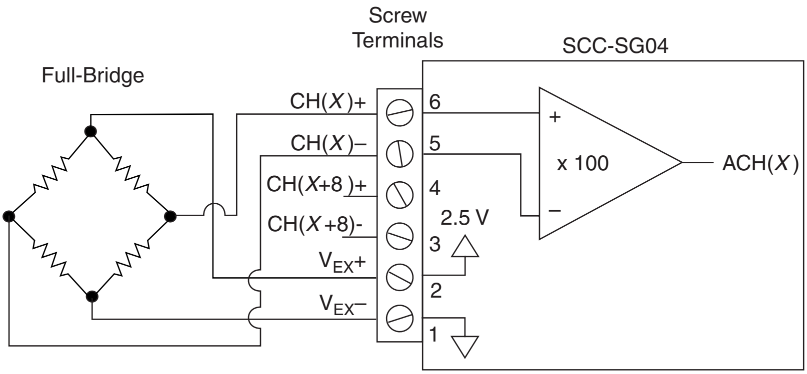


Figure 4-29. SCC-SG04 Full-Bridge Connection

Excitation

Each SCC-SG0*X* contains an onboard voltage source for Wheatstone bridge excitation. You can use this onboard-regulated +2.5 VDC excitation source to power your strain-gauge bridges. This excitation supply can supply up to 42 mA, which is enough to drive two 120 Ω strain-gauge bridges. Optionally, you can connect an external excitation source across your strain-gauge bridges.

Offset Nulling Adjustment

Each SCC-SG0*X* has circuitry for offset nulling adjustment of Wheatstone bridges. The nulling circuitry uses the excitation voltage as a reference and operates with full-bridge, half-bridge, and quarter-bridge strain-gauge configurations. Each channel has its own nulling circuit with a trimming potentiometer to adjust the nulling voltage level. These potentiometers are accessible on top of the SCC and are clearly marked X for CH(*X*) offset nulling and X+8 for CH(*X*+8) offset nulling. The offset nulling circuitry has the added advantage of nulling the offset voltages of your entire signal path including the bridge, the SCC-SG0X channel, and the E Series DAQ device analog input channel.

To null the static voltage offset of the system including the bridge, use the following procedure:

1. Configure and connect your bridge to an SCC-SG0*X* channel.
2. Read the channel.
3. While monitoring the channel input voltage, rotate the appropriate trimming potentiometer wiper with a flathead screwdriver until you read 0 V.

You have nulled your system offset and you are ready to make measurements.

Nulling Range Adjustment

The nulling range of the offset adjust nulling circuitry is approximately ±2.5 mV referred to input (RTI), assuming an excitation voltage of 2.5 V. The nulling circuitry of each channel has a resistor that sets this nulling range. You can change the nulling range of the offset nulling circuitry for each channel by replacing its nulling resistor with a resistor of another value. Therefore, you can mix your ranges to accommodate each channel requirement. Nulling resistor R1 corresponds to channel CH(*X*). Nulling resistor R5 corresponds to channel CH(*X*+8).

The value of all the nulling resistors on the SCC-SG0*X* is 30 kΩ. Notice that these resistors are socketed for easy replacement. The sockets best fit a 1/4 W resistor lead size.

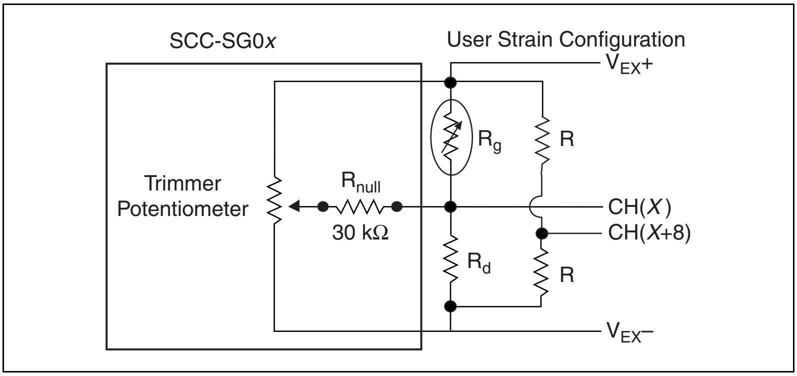


Figure 4-30. SCC-SG11 Connection

To determine your nulling range, use the following formula while referring to the Figure 4-30:

$$V_{nulling} = \pm\left|\frac{V_{ex}}{2} - \frac{V_{ex}R_d(R_{null} + R_g)}{R_{null}R_g + R_d(R_{null} + R_g)}\right|$$

where

R_g is the nominal strain-gauge resistance value.

R_d is either a completion resistor or the nominal resistance of a second strain-gauge.

R_{null} is the nulling resistor value.

V_{ex} is the excitation voltage (built-in = 2.5 V).

For example, assuming: V_{ex} = 2.5 V

R_g = 120 Ω

R_d = 120 Ω

R_{null} = 30 kΩ

$V_{nulling}$ = ±2.5 mV

Assuming a strain-gauge range with a gauge factor of GF = 2 and a quarter-bridge configuration, this range corresponds to ±2,000 με as given by the following strain formula for a quarter-bridge.

$$\varepsilon = \frac{-4V_r}{GF(1 + 2V_r)}$$

where

$$V_r = \frac{\text{strained voltage} - \text{static unstrained voltage}}{V_{ex}}$$

Filtering

Each channel on the SCC-SG0*X* has a postgain, lowpass filter. This filter is a single-pole, buffered, RC filter with a cutoff frequency of 1.6 kHz.

Shunt Calibration

The SCC-SG11 shunt calibration module is keyed and has the icon shown in Figure 4-31.

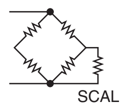


Figure 4-31. SCC-SG11 Icon

You must plug the SCC-SG11 into the first-stage analog input socket of the SC-2345 for the channels in which you connect the SCC-SG0*X*, as shown in Figure 4-32.

Note This is an SCC dual-stage configuration, but is not dual-stage conditioning. Your strain-gauge leads always connect to the SCC-SG0*X*. You must supply additional leads for connection to the SCC-SG11 shunt calibration module.

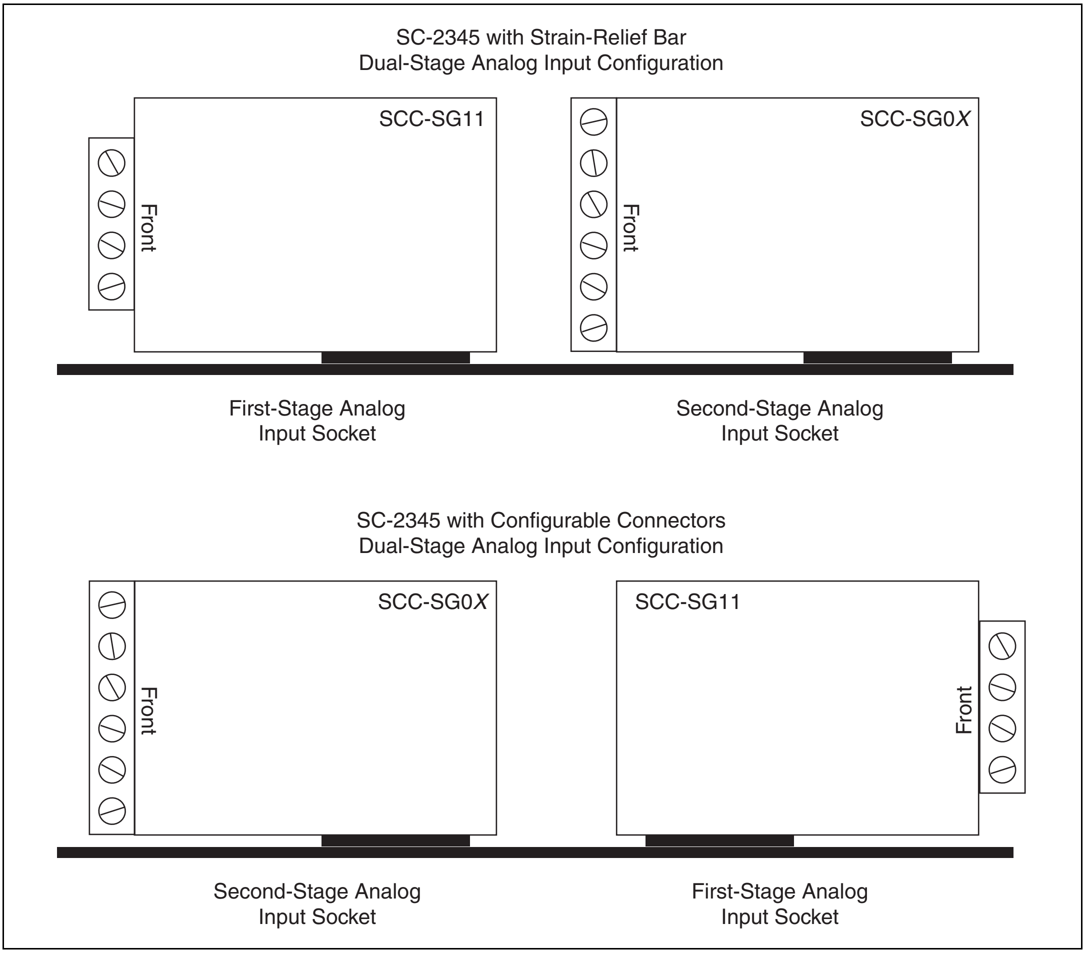


Figure 4-32. Dual-Stage Analog Input Configuration for SCC-SG0*X* and SCC-SG11 Installed in an SC-2345

The SCC-SG11 contains two shunt calibration circuits each consisting of a 301 kΩ shunt calibration resistor and relay. The circuits are independent of each other, but are controlled together. The relays are controlled by a single E Series device digital output DIO(*X*). When DIO(*X*) is set to 1 on the E Series device, the shunt calibration circuits are enabled and the LED indicator on the SCC is lit. When DIO(*X*) is set to 0, the circuits are disabled and the LED indicator on the SCC is off. At startup or reset, the circuits are disabled. When enabled, the shunt calibration resistor is in line with the SCC-SG11 screw terminals. This allows you to place a shunting resistor in parallel with a strain gauge as shown in Figure 4-33.

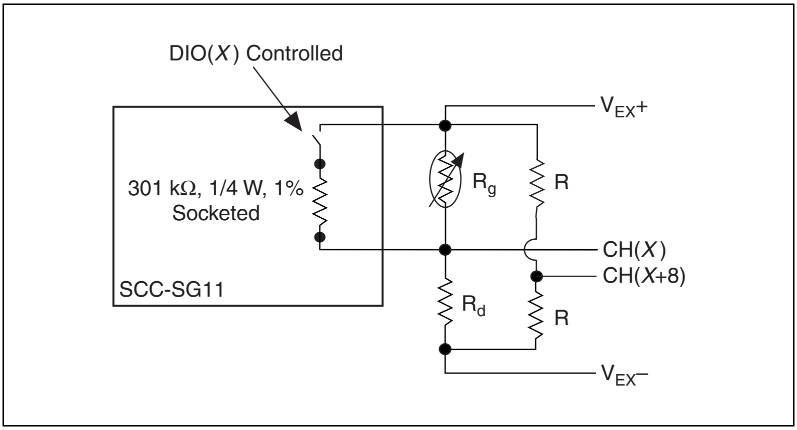


Figure 4-33. SCC-SG11 Connection

The shunting resistors on your SCC-SG11 have a 301 kΩ ±1% value. These resistors are socketed so you can replace them with a resistor of another value to achieve the required changes.

Assuming a quarter-bridge strain-gauge configuration with a gauge factor of GF = 2, the equivalent strain change introduced by the shunting resistor is –498 με. You can determine the change as follows:

1. Determine the change caused by the shunting resistor using the following formula:

$$V_{change} = \frac{R_d V_{ex}(R_{SCAL} + R_g)}{R_g R_{SCAL} + R_d(R_{SCAL} + R_g)} - \frac{V_{ex}}{2}$$

   where

   V_{ex} is the excitation voltage which is 2.5 V.

   R_d is either a completion resistor or a second strain-gauge nominal resistance.

   R_{SCAL} is the shunting resistor.

   R_g is the nominal strain-gauge resistance value.

2. Using the appropriate strain-gauge strain formula, assuming that you have no static voltage, determine the equivalent strain that the R_{SCAL} should produce. For example, R_{SCAL} = 301 kΩ and a quarter-bridge 120 Ω strain gauge with a gauge factor of GF = 2 and V_{ex} = 2.5 V and R = 120 Ω produces the following result:

$$V_{change} = 0.2491 \text{ mV}$$

Replacing the strained voltage with V_{change} in the quarter-bridge strain equation produces an equivalent 498 με of change.

Measurement Scaling Considerations

Notes NI-DAQ includes voltage to strain conversion utilities that implement the conversions shown below. Refer to your software documentation for more information on these utilities.

You *cannot* use DAQ Virtual Channels within the Data Neighborhood of Measurement & Automation Explorer to scale strain-gauge measurements into units of strain.

Your software environment may only return voltage measurements from your E Series device. In this case, you must convert your voltage measurement to a microstrain measurement. To make this conversion, perform the following steps:

1. Measure the strain-gauge voltage by performing the following:
   a. Read the strain-gauge channel on the E Series device V_{eseries} [CH(*X*)].
   b. Calculate the strain-gauge voltage by using the following formula:

   $$V_{SG} = \frac{V_{eseries}}{100}$$

   where

   VSG is strain-gauge voltage.

   V_{eseries} is E Series device voltage.

   This step provides proper scaling for the strain-gauge amplifier in the SCC-SG0*X*.
2. Now perform the appropriate strain-gauge conversion for your type of strain-gauge configuration.

Note The SCC-SG0*X* built-in voltage excitation equals 2.5 V.

SCC-TC Thermocouple Input Modules

The SCC-TC thermocouple input modules, SCC-TC01 and SCC-TC02, accept input signals from B, E, J, K, N, R, S, and T-type thermocouples. The thermocouple inputs are filtered and passed into a differential amplifier with a gain of 100. The output of the amplifier passes through a dual-pole 2 Hz filter and is buffered to allow maximum scan rates. The amplified thermocouple signal connects to an E Series device channel 0 through 8, depending on the SC-2345 socket where you plug the SCC-TC. Each SCC-TC contains thermistor circuitry powered by a 2.5 V reference for compensating cold-junction effects. This thermistor output connects to any single-ended channel 8 through 15, depending on the socket where you plug the SCC-TC. Each SCC-TC can also detect open thermocouple circuits.

The SCC-TC01 contains a two-prong uncompensated thermocouple miniconnector that accepts any miniature or subminiature two-prong male thermocouple connector. The SCC-TC02 contains a three-position screw terminal connector that accepts 28 to 16 AWG thermocouple wires. This three-position screw terminal allows for a ground connection when using shielded thermocouples. Otherwise, the two modules function identically.

The SCC-TC02, because of its screw terminal connections, can also function as a low-bandwidth, millivolt input module. Due to the gain of 100, the maximum input is ±100 mV. You can read this input voltage on any E Series device single-ended channel 0 through 7. Figure 4-34 shows the SCC-TC icon.

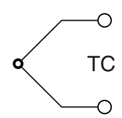


Figure 4-34. SCC-TC Icon

You can plug the SCC-TC thermocouple modules into any single-stage analog input SCC socket.

To use an SCC-TC01, plug your thermocouple miniconnector into the SCC and install the module into the SC-2345.

To use an SCC-TC02, attach your signal wires to the onboard screw terminals and install the SCC into the SC-2345. Each screw terminal component is labeled; connect the wires accordingly. Typically the red thermocouple wire is negative. The SCC-TC02 accepts up to three signals: TC+, TC–, GND. The GND terminal connects to AIGND on the E Series device and is available if you use a shielded thermocouple.

The SCC-TC has a 10 MΩ bias resistor connected from the negative thermocouple input to ground. This resistor allows your thermocouple to be ground-referenced or floating without first having to add bias resistors.

The amplified thermocouple and the cold-junction sensor signals are measured by the E Series device channel *X* and channel *X*+8 respectively, where *X* is 0 through 7 and *X*+8 is 8 through 15 depending on the SC-2345 socket used. See Figure 4-35 for SCC-TC signal connections.

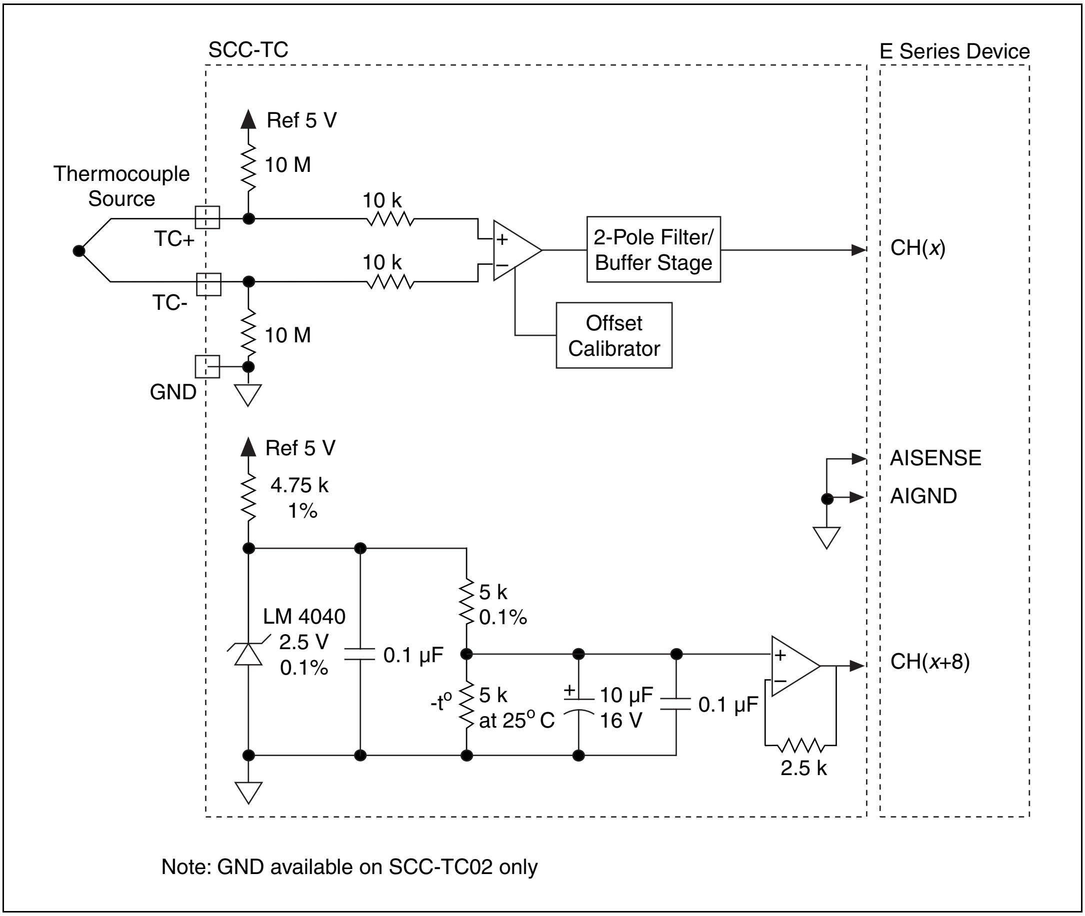


Figure 4-35. SCC-TC Signal Connection

Cold-Junction Sensor Output and Accuracy

The cold-junction sensor voltage output varies from 1.91 to 0.58 V over a 0 to 55 °C temperature range.

Note NI-DAQ includes thermistor conversion utilities that implement the equations listed below. Refer to your software documentation for more information on these utilities.

You can use the following formulas to convert the cold-junction sensor voltage to cold-junction temperature:

$$T(°C) = T_K - 273.15$$

where T_K is the temperature in kelvin

$$T_K = \frac{1}{[a + b(\ln R_T) + c(\ln R_T)^3]}$$

$a = 1.295361 \times 10^{-3}$

$b = 2.343159 \times 10^{-4}$

$c = 1.018703 \times 10^{-7}$

R_T = resistance of the thermistor in ohms

$$R_T = 5,000\left(\frac{V_{TEMPOUT}}{2.5 - V_{TEMPOUT}}\right)$$

$V_{TEMPOUT}$ = output voltage of the cold-junction sensor

$$T(°F) = \frac{[T(°C)]9}{5} + 32$$

where *T(°F)* and *T(°C)* are the temperature readings in degrees Fahrenheit and Celsius, respectively.

Note $V_{TEMPOUT}$ varies from 1.91 V (at 0 °C) to 0.58 V (at 55 °C). For best resolution, use the maximum gain for this range on the analog input channel.

For the cold-junction sensor measurement accuracy, refer to Appendix A, *Specifications*.

Open-Thermocouple Detection

The SCC-TC contains a 10 MΩ pull-up resistor that connects to +5 V to detect an open thermocouple. To determine if you have an open thermocouple, check whether the corresponding E Series channel is saturated. The pull-up and bias resistors saturate the channel by applying +2.5 V at the input of an open channel. This results in saturation to either the positive or negative rails of the E Series device (+9.99 V or –10 V).

Errors Due to Open-Thermocouple Detection Circuitry

The open-thermocouple detection circuitry can cause measurement errors. These errors are the results of common-mode voltage at the input of the SCC and current leakage into your signal leads. The 10 MΩ bias resistor in the SCC-TC causes this error to be negligible. With the 10 MΩ bias resistor connected to ground and the 10 MΩ pull-up resistor connected to +5 VDC, a current leakage of approximately 0.25 µA (5 V/20 MΩ) flows into the unbroken floating thermocouple. Long thermocouple leads result in larger voltage drops due to lead resistance.

For example, if you have a 24 AWG J-type thermocouple that is 20 ft long, a voltage drop of approximately

$$4.39\ \mu V\ (0.878\ \Omega\ /\text{double ft} \times 20\ \text{double ft} \times 0.25\ \mu A)$$

can develop in the thermocouple, which corresponds to an error of 0.09 °C.

With 10 MΩ pull-up and bias resistors, a common-mode voltage of +2.5 VDC develops if the thermocouple is floating. The common-mode rejection of the SCC-TC is sufficiently high, which results in the offset voltage being negligible in most applications.

If your application demands extremely high accuracy, you can eliminate these errors by calibrating your system. See the *Calibrating System Offsets* section in this chapter for more information.

Calibrating System Offsets

You can calibrate the SCC in-system using your E Series device. The following procedure requires a minimum 10 minute warm-up prior to calibration:

1. Select the desired channel and gain on the E Series device.
2. Short the inputs on the SCC screw terminals or miniplug.
3. While acquiring data on the selected channel, use a screwdriver to adjust the potentiometer protruding through the top of the SCC until you read 0 VDC.

This procedure calibrates the SCC-TC for minimum error at 0 °C. Alternatively, you can calibrate the SCC-TC for minimum errors at temperatures other than 0 °C using a thermocouple calibrator.

Calibrating Your System Using a Thermocouple Calibrator

To calibrate your system using a thermocouple calibrator, first make sure that the temperature of the thermocouple connections at both the SCC and the thermocouple calibrator are the same.

For best results, use thermocouple wire of the same length and type that you use in your thermocouple, as shown in Figure 4-36.

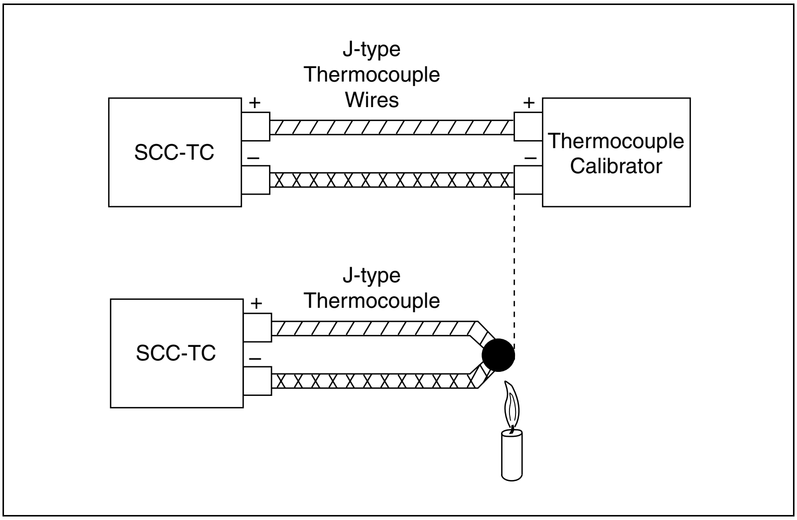


Figure 4-36. Thermocouple Calibration Configuration

Follow these steps to calibrate your system:

1. Connect the thermocouple wires from the thermocouple calibrator to the SCC.
2. Set the thermocouple calibrator to the required calibration temperature.
3. Measure the thermocouple temperature using the SCC.
4. Adjust the potentiometer on the top of the SCC so that the measured temperature is equal to the calibration temperature.

Measurement Conversion Considerations

Note NI-DAQ includes thermocouple and thermistor conversion utilities that implement the conversions required in steps three and five below. Refer to your software documentation for more information on these utilities.

Your software environment may only return voltage measurements from your E Series devices. In this case, you must convert your voltage measurement to a temperature measurement. To make this conversion, perform the following steps:

1. Measure the thermocouple voltage by performing the following:
   a. Read the thermocouple channel on the E Series DAQ device $V_{eseries}$ [CH(X)].
   b. Calculate the thermocouple voltage by using the following formula:

$$V_{tc} = \frac{V_{eseries}}{100}$$

   where

   V_{tc} is thermocouple voltage.

   $V_{eseries}$ is E Series device voltage.

   This step provides proper scaling for the thermocouple amplifier in the SCC-TC.

2. Measure the reference-junction (cold-junction) temperature by performing the following:
   a. Read the thermistor voltage [CH (X+8)].
   b. Convert the thermistor voltage to cold-junction temperature using the formula in the *Cold-Junction Sensor Output and Accuracy* section.

3. Calculate the cold-junction compensation voltage by converting the cold-junction temperature you got in step 2 to a thermocouple voltage. Use the polynomial expressions that are applicable to your thermocouple type.
4. Apply the cold-junction compensation to the thermocouple reading by adding the cold-junction compensation voltage you got in step 3 to V_{tc}.
5. Calculate the thermocouple temperature by converting the voltage result you got in step 4 to a temperature. Use the polynomial expressions that are valid for your thermocouple type. This gives you a linearized temperature measurement.

Note Polynomials come from the NIST Monograph 175.

SCC-FT01 Feedthrough Module

The SCC-FT01 is a feedthrough module for directly connecting to analog input or analog output channels. You can modify the SCC-FT01 to create a custom signal conditioning module. The SCC-FT01 contains a breadboard area for custom conditioning and connection to both analog and digital signals on the E Series device. Figure 4-37 shows the SCC-FT01 icon.

Figure 4-37. SCC-FT01 Icon

You can plug the SCC-FT01, as shipped, into any analog input or analog output socket in the carrier. When used as a prototyping module, the SCC-FT01 plugs into any socket on the SC-2345 except the power socket.

Caution If you plug the SCC-FT01 into any other type of SCC socket, you can damage the E Series device.

To modify the SCC-FT01 to perform custom signal conditioning, see the *Customizing the SCC-FT01* section later in this chapter.

Signal Connections

After installing the SCC-FT01, attach your signal wires to the screw terminals of the SCC-FT01. Each screw terminal is labeled numerically and the label is identified with signal names. Connect the wires accordingly.

The SCC-FT01 accepts up to five signals: CH+, CH–, AIGND, AISENSE, and EXTREF. Table 4-4 shows the signals available if you plug the SCC-FT01 into analog input single-stage SCC socket J1 or analog output SCC socket J17.

Table 4-4. SCC-FT01 Signals

Screw Terminal Label	Analog Input Single-Stage SCC Socket J1	Analog Output SCC Socket J17
CH+	ACH0	DAC0 (DAC(A))
CH–	ACH8	AOGND0 (AOGND(A))
AIGND	AIGND	PFI5
AISENSE	AISENSE	DAC1 (DAC(B))
EXTREF	N/A	EXTREF

When you plug the SCC-FT01 into a single-stage analog input SCC socket, the following conditions are true:

- CH+ connects to the lower analog input channel number indicated (CH0 through CH7).
- CH– connects to the higher analog input channel number indicated. (CH8 through CH15).
- AIGND connects to analog input ground.
- AISENSE connects to AISENSE.
- EXTREF does not connect and should not be used.

Because the E Series device is configured in the NRSE analog input configuration, you must connect your source to single-ended channels on the SCC-FT01.

When you plug the SCC-FT01 into an analog output SCC socket, the following conditions are true:

- CH+ connects to the analog output channel number indicated.
- CH– connects to the analog output ground of the channel indicated.
- AIGND connects to PFI5.
- AISENSE connects to the second analog output channel.
- EXTREF connects to EXTREF.

Customizing the SCC-FT01

You can customize the SCC-FT01 to connect to any of the analog input, analog output, DIO, or GPCTR signals of the E Series device. After you customize your SCC-FT01, you can plug it into any SCC socket on the SC-2345 except the SCC power socket. The SCC-FT01 PWB contains 1 sq in. of prototyping breadboard area. This area accommodates as many as four 8-pin ICs and other discrete components, such as resistors and capacitors.

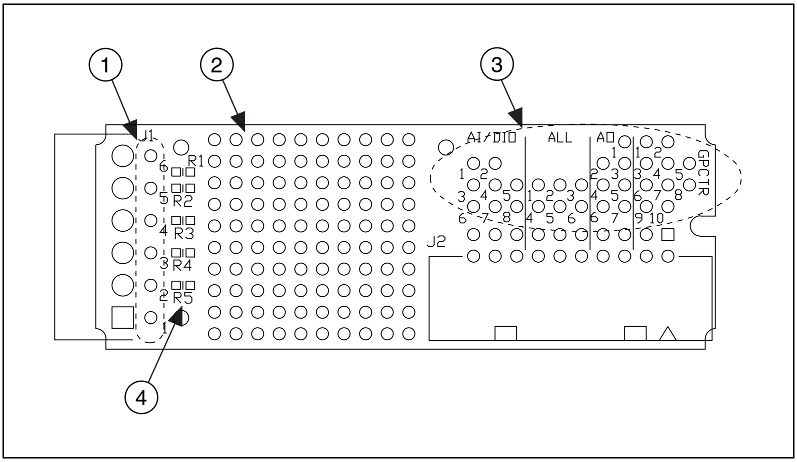
Place the SCC-FT01 prototyping module label, which is included in your kit, over the SCC-FT01 feedthrough module label on the SCC enclosure. This label does not contain signal names because you will be customizing the pin assignments of the screw terminals.

Circuit Design

You must disassemble the SCC-FT01 to install custom circuitry. To open the module:

1. Remove the screw from the back (wide unlabeled side).
2. Turn the front (wide label side) toward you.
3. Place the screw terminal receptacle on the left.
4. Slide the top cover to the right.
5. Lift off the cover.

You *must* remove resistors R1 through R5, shown in Figure 4-38, when you develop your circuitry.



1	I/O Pads	3	Signal Connection Pads
2	Prototyping Breadboard Area	4	R1 through R5

Figure 4-38. SC-FT01 Parts Locator Diagram

The signal connection pads above connector J2 connect to different signals on the E Series device, depending on where you install the SCC-FT01 on the SC-2345. Table 4-5 shows the signals available for circuit design when you plug the SCC-FT01 into each type of SCC socket on the SC-2345. The pad numbers correspond to the number next to each pad on the SCC-FT01.

Table 4-5. Signals Available by SCC Socket Type

Pad Number	Signal Name				
	AI/DIO	**AO**	**All**	**GPCTR CH0**	**GPCTR CH1**
1	AISENSE	EXTREF	–15V	PFI8/ GPCTR0_SOURCE	PFI3/ GPCTR1_SOURCE
2	ACH+	DAC(B)	REF5V	PFI6/WFTRIG or ACH– Cascaded REF†††	EXTSTROBE* or ACH– Cascaded REF†††
3	AIGND	AOGND(B)	GND (+5V)	N/A or ACH+ Cascaded REF†††	PFI1/TRIG2 or ACH+ Cascaded REF†††
4	PFI7/STARTSCAN†DIO(X) ††	AOGND(A)	+15V	FREQ_OUT	FREQ_OUT
5	ACH–	DAC(A)	GND (15V and REF5V)	PFI5/UPDATE*	SCANCLK
6	ACH+ Cascaded†	PFI6/WFTRIG	+5V	DIO6	DIO7
7	ACH– Cascaded†	PFI5/UPDATE*	N/A	PFI0/TRIG1	PFI0/TRIG1
8	AISENSE Cascaded†	N/A	N/A	N/A	PFI7/STARTSCAN
9	N/A	N/A	N/A	PFI9/ GPCTR0_GATE	PFI4/ GPCTR1_GATE
10	N/A	N/A	N/A	GPCTR0_OUT	GPCTR1_OUT

† Available on final-stage analog input SCC sockets (J1 to J8) only
†† Available on DIO SCC sockets (J9 to J16) only
††† Not a GPCTR signal name. Available on any analog input SCC socket J1 through J8

An SCC-FT01 signal connection label, which defines the pad numbers on the SCC-FT01 board, is attached to the cover of the SCC enclosure.

Whether you plug the SCC-FT01 into an SCC socket for analog input, analog output, DIO, or GPCTR conditioning, the pads listed under *All* in Table 4-5 are connected; you can use these pads.

Wiring Considerations

The following sections contain signal wire considerations for the SCC-FT01 prototype circuit. The signal names in the following sections refer to the signals in Table 4-5.

Note When you plug the SCC-FT01 into the first-stage socket of dual-stage analog input SCC sockets on the SC-2345, you do *not* connect the outputs of your circuitry to the pads labeled Cascaded. Use pads labeled Cascaded only when you plug the SCC-FT01 into the second-stage (final-stage) socket to get your input signals through the SC-2345 from the first-stage socket. Refer to Figure 4-39a and Figure 4-39b.

Analog Input and Digital Input/Output

If you plug the SCC-FT01 into any analog input SCC socket J1 to J16 on the SC-2345, use the pads above connector J2 labeled AI/DIO for connections to the breadboard area. The signals available are slightly different when plugged into the first-stage analog input (also known as DIO) than when plugged into the second-stage analog input (also known as single-stage analog input). Use SCC sockets J9 to J16 for first-stage analog input. Use SCC sockets J1 to J8 for second-stage analog input.

PFI7/STARTSCAN, ACH+ Cascaded, ACH+ Cascaded REF, ACH– Cascaded, ACH– Cascaded REF, and AISENSE Cascaded signals are available for the second-stage analog input SCC sockets only. The DIO*X* signal is available for the first-stage analog input SCC sockets only. Refer to Table 4-5 for pad definitions.

Remember, the E Series device is configured in the NRSE analog input configuration. This means you must design your prototype circuitry so that the output of the SCC-FT01 to the E Series device is single-ended referenced to AIGND.

Figure 4-39a and 4-39b illustrates example wiring for the SCC-FT01 prototyping module used in dual-stage analog input configuration. Figure 4-39c illustrates single-stage the analog input configuration.

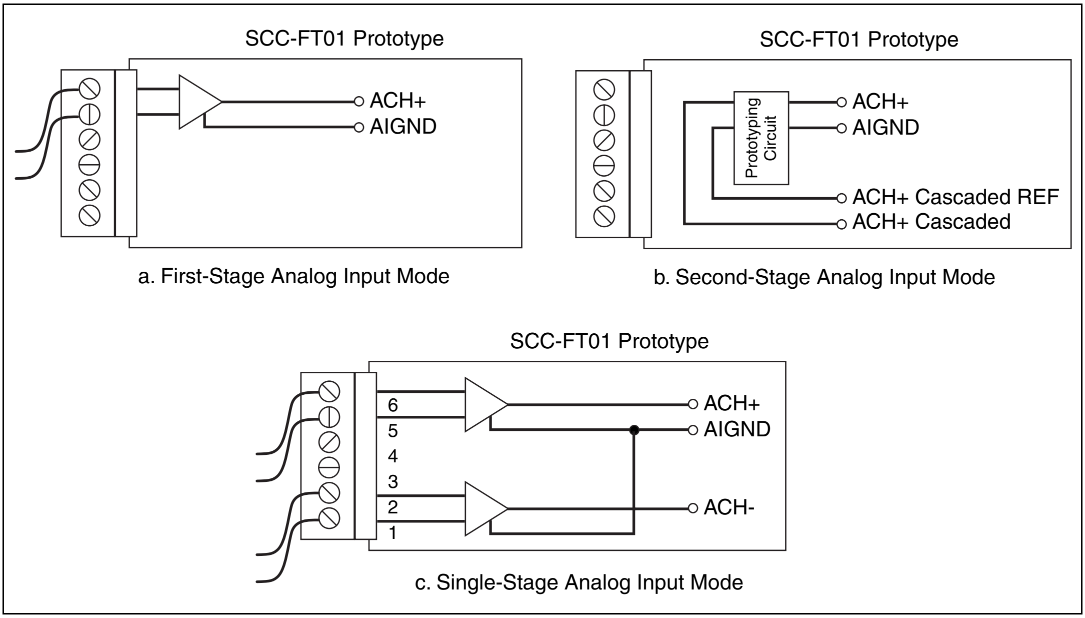


Figure 4-39. SCC-FT01 Prototyping Module Analog Input Configurations

Analog Output

If you plug the SCC-FT01 into any analog output socket on the SC-2345, use the pads listed in the *AO* column in Table 4-5. The DAC(A), AOGND(A), DAC(B), and AOGND(B) signals depend on which SCC socket on the SC-2345 you use. For example, if you plug the SCC-FT01 into the analog output CH0 socket (J17), the DAC(A) and AOGND(A) pads connect to DAC0 and AOGND0, while the DAC(B) and AOGND(B) pads connect to DAC1 and AOGND1, respectively, on the E Series device.

GPCTR

If you plug the SCC-FT01 into any GPCTR socket on the SC-2345, use the pads listed under the *GPCTR CH0* and *GPCTR CH1*columns in Table 4-5. The signals available depend on which SCC socket on the SC-2345 you use.

If you plug the SCC-FT01 into the GPCTR CH0 socket (J19), the pads under GPCTR CH0 on the board connect to signals associated with GPCTR channel 0 and analog output of the E Series device. When the SCC-FT01 is plugged into the GPCTR CH1 socket (J20), the pads under GPCTR CH1 on the board connect to signals associated with GPCTR channel 1 and analog input of the E Series device.

Screw Terminal Connection

The pads next to connector J1 connect to each pin of the screw terminal connector. Use these pads to connect your external signals to the circuitry you added in the breadboard area. The numbers next to each hole correspond to the numbers on the screw terminals. Space is available on the SCC-FT01 prototyping module label for custom signal names.

SCC-DI01 Isolated Digital Input Module

The SCC-DI01 is a single-channel optically isolated digital input module. You can sense digital levels up to 30 VDC. Because the SCC-DI01 is optically isolated, you can decouple the noise and harsh ground of the PC from the real-world signals and vice versa.

Caution Connections that exceed any of the maximum ratings of input signals on the SCC-DI01 may damage your SCC-DI01, your E Series device, and your computer. This warning includes connecting any power signals to ground and vice versa. National Instruments is not liable for any damages resulting from any such signal connections.

A green label stripe identifies the SCC-DI01 as a digital component. Figure 4-40 shows the icon that represents the SCC-DI01.

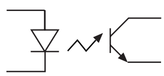


Figure 4-40. SCC-DI01 Icon

You can plug the SCC-DI01 into any DIO socket on the SC-2345.

Signal Connections

The SCC-DI01 contains optically isolated inputs consisting of a bidirectional LED and a resistor for current limiting. It has its own isolated ground and input signal. Depending on which socket on the SC-2345 you plug the SCC-DI01 into, you can access a single DIO line 0 through 7. Figure 4-41 shows the SCC-DI01 signal connections.

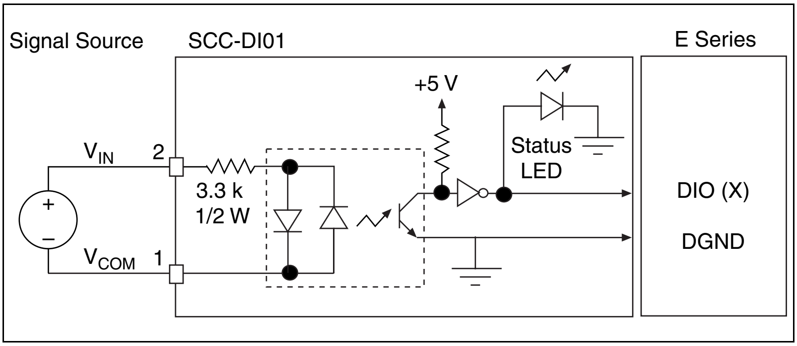


Figure 4-41. SCC-DI01 Signal Connections

Status LED

The SCC-DI01 contains a status LED to indicate when an input signal registers a logic high or a logic low. The LED is located above the two-position connector. If the LED is off, the input signal is registering a logic low on the DIO line. If the LED is on, the input signal is registering a logic high on the DIO line.

Sensing DC Voltages

When a positive or negative DC voltage with a magnitude of at least 2 V is referenced to V_{COM} and is applied to the input, the SCC-DI01 registers a logic high for that input. If no voltage is present, the SCC-DI01 registers a logic low for that input. Therefore, you can use the SCC-DI01 to sense a wide range of DC signals from digital logic levels to DC power supply levels up to 30 V.

Sensing AC Voltages

The SCC-DI01 senses a wide range of AC signals by registering a constant high while an AC voltage (referenced to V_{COM}) is present at an input. Signals with low amplitude and low frequency appear as signals that are alternately turned on and off; therefore the SCC-DI01 alternately registers logic highs and logic lows for that signal. For sinusoidal signals, a 1 kHz and higher frequency signal with a voltage of at least 4 V_{rms} returns a constant logic high level.

Signal Isolation

The V_{IN} and V_{COM} signals are isolated from the inputs of other channels and are also isolated from the SCC-DI01 internal power and ground signals. These barriers isolate voltages up to +42 V and protect the SCC-DI01. Voltages higher than the +42 VDC can damage your equipment.

Caution You must *not* exceed the voltage limit of the V_{IN} signals referenced to their respective V_{COM} signals. National Instruments is *not* liable for any damages resulting from any such signal connections.

Power-On Condition

At power up, the SCC-DI01 registers a logic low if there are no connections to the inputs.

SCC-DO01 Isolated Digital Output Module

The SCC-DO01 is a single-channel, optically isolated digital output module. You can switch external devices, such as transistors and solid-state relays. Because the SCC-DO01 is optically isolated, you can decouple the noise and harsh ground of the PC from the real-world signals and vice versa.

Caution Connections that exceed any of the maximum ratings of input signals on the SCC-DO01 may damage your SCC-DO01, your E Series device, and your computer. This warning includes connecting any power signals to ground and vice versa. National Instruments is not liable for any damages resulting from any such signal connections.

A green label stripe identifies the SCC-DO01 as a digital component. Figure 4-42 shows the icon that represents the SCC-DO01.

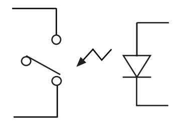


Figure 4-42. SCC-DO01 Icon

You can plug the SCC-DO01 into any DIO socket on the SC-2345.

Signal Connections

The SCC-DO01 contains optically isolated outputs consisting of a photomos relay and a load resistor. It has its own isolated ground and output signal. Depending on which socket on the SC-2345 you plug the SCC-DO01 into, you can access a single DIO line 0 through 7. Figure 4-43 shows the SCC-DO01 signal connections for optional loads.

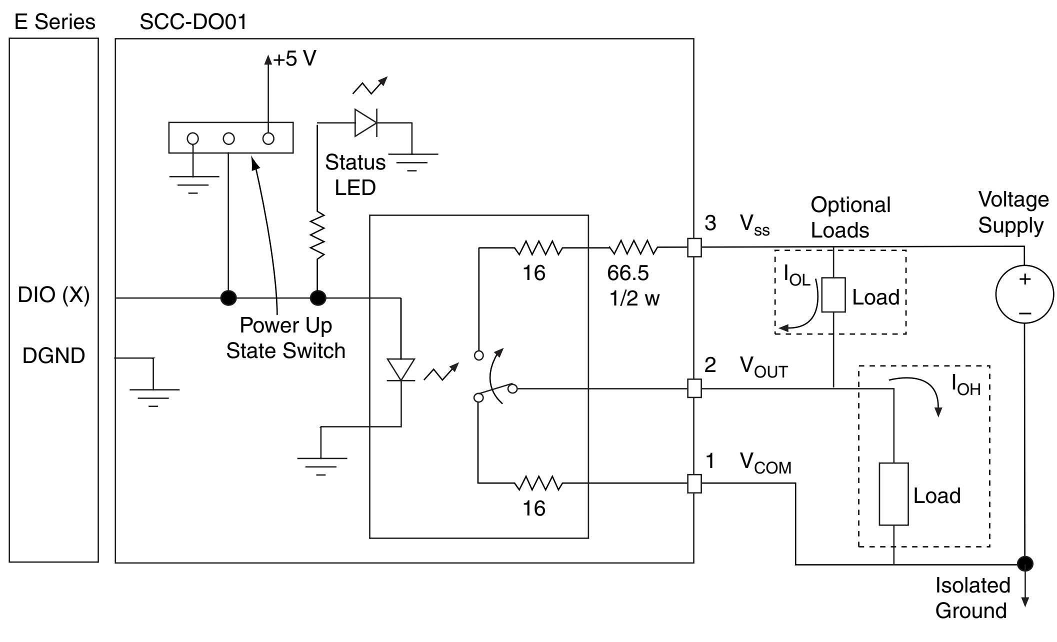


Figure 4-43. SCC-DO01 Signal Connections

Status LED

The SCC-DO01 contains a status LED to indicate when the output signal registers a logic high or a logic low. The LED is located above the three-position connector. If the LED is off, the output signal is registering a logic low on the DIO line. If the LED is on, the output signal is registering a logic high on the DIO line.

Signal Isolation

The V_{COM}, V_{SS}, and V_{OUT} signals of each channel are isolated from outputs of other channels and also isolated from the SCC-DO01 internal power and ground signals. These barriers isolate for voltages up to +42 VDC and protect the SCC-DO01. Common-mode voltages higher than the +42 VDC can damage your equipment.

Power-On Condition

The SCC-DO01 contains a switch for setting the power-up state of the SCC-DO01. When switched to *H*, V_{OUT} will be V_{SS}. When switched to *L*, V_{OUT} will be V_{COM}. The factory setting of the power-up state is *L* or V_{COM}.

A
Specifications

This section lists the specifications of the SC-2345, the SCC Power series modules, and the SCC modules. These ratings are typical at 25 °C unless otherwise stated.

SC-2345

Analog

I/O connections .... 16, 20-pin connectors for analog input
2, 20-pin connectors for analog output
1, 20-pin connector for external power

Number of input channels .... 16 SE

Number of output channels 2

Stability

Onboard calibration reference

- Level .... 5.000 V ±2.5 mV
- Temperature coefficient .... ±5 ppm/°C max
- Long-term stability .... ±15 ppm/ $\sqrt{1,000\ \text{h}}$
- Load regulation
  - Sourcing $0 < I_{OUT} < 10$ mA ..... 100 µV/mA
  - Sinking $-10 < I_{OUT} < 0$ mA ..... 400 µV/mA

Power Requirement

+15 VDC .... 2 mA (0.03 W)[1]

Digital

I/O connections .... 8, 20-pin connectors for DIO (shared with analog input), 42-position, triple-row terminal block

Physical

SC-2345 Connector Block

Dimensions .... 24.1 by 26.2 by 3.937 cm (9.5 by 10.3 by 1.55 in.)

I/O connectors... 1, 68-pin male SCSI connector
1, 6-pin male connector

SC-2345 Configurable Connector (Rear and Side Cabled)

Dimensions .... 30.63 by 25.40 by 4.39 cm (12.06 by 10.00 by 1.73 in.)

I/O connectors... User-defined panelettes
1, 68-pin male SCSI connector
1, 6-pin male connector

Environment

Operating temperature .... 0 to 70 °C

Storage temperature................................ –55 to 125 °C

Relative humidity .... 5 to 90% noncondensing

SCC Power Series Modules

SCC-PWR01

Input

DC input voltage .... +5 VDC ±5% (from an external power source)
or
+5 VDC from an E Series device

DC input power .... 750 mW without SCC

Output

	Nominal Voltage		
	+5 VDC	**+15 VDC**	**–15 VDC**
Voltage range	+4.4 to +5.25 VDC	+14.20 to +15.25 VDC	–14.20 to –15.25 VDC
Max power available, Power source:			
AT/PCI E Series device	1.75 W (390 mA)*	0.75 W (50 mA)*	0.75 W (50 mA)*
DAQCard/DAQPad E Series device	0.5 W (100 mA)**	0.36 W (24 mA)**	0.36 W (24 mA)**
External power	Dependent on source	1 W (67 mA)	1 W (67 mA)
Efficiency	100%	62%	62%
Line regulation	System dependent	±0.5% typ	±0.5% typ
Load regulation	System dependent	±0.1% typ	±0.1% typ
Ripple and noise Bandwidth = DC to 10 MHz	System dependent	15 mV_{rms} typ	20 mV_{rms} typ

* The SCC-PWR01 should be used only with a 68-pin E Series cable that is ≤ 2 m long. This is due to increased cable impedance in longer cables. To guarantee 4.5 V at the SCC-PWR01 input, limit current draw from the E Series device to 540 mA max. Combined max power = $[(P_A / 0.62) + P_D] \leq 2.4$ W

** Combined max power = $[(P_A / 0.62) + P_D] \leq 1.14$ W

P_A = total analog power
P_D = total digital power

Physical

Screw terminal..24 to 16 AWG

SCC-PWR02

Input

AC input voltage.....................................90 to 264 VAC

AC input frequency ....47 to 63 Hz

AC input current ....1.0 A max

In-rush current (at cold start)..................30 A max

Output

	Output Voltage		
	+5 VDC	+15 VDC	–15 VDC
Voltage range	+4.64 to +5.25 VDC	+14.45 to +15.25 VDC	–14.45 to –15.25 VDC
Max power available	5 W (1.0 A)	4.5 W (0.3 A)	4.5 W (0.3 A)
Line regulation	±1%	±5%	±5%
Load regulation	±5%	±10%	±10%
Ripple and noise Bandwidth = DC to 10 MHz	20 mV_{rms} typ	20 mV_{rms} typ	20 mV_{rms} typ

Overall Performance

Max output...14 W

Efficiency..65% typ

Switching frequency ....50 kHz nominal

Other Features

Short circuit protection........................... Yes

Overvoltage protection........................... 343 VAC

Dimensions of the external supply......... 15.5 by 8.5 by 4.8 cm (6.1 by 3.3 by 1.9 in.)

Environment for External Supply

Operating temperature............................ 0 to 40 °C

Storage temperature .... –20 to 80 °C

Relative humidity................................... 0 to 90% noncondensing

SCC-PWR03

Input

DC input voltage .... 7 to 42 VDC

DC input current..................................... 0.25 A min (dependent on SCC modules installed)

Output

	Output Voltage		
	+5 V ±5%	+15 VDC ±5%	–15 VDC ±5%
Max power available	†	1 W (67 mA)	1 W (67 mA)
Efficiency	75%††	46%†††	46%†††
Line regulation	±1%	±5%	±5%
Load regulation	±5%	±10%	±10%
Ripple and noise Bandwidth = DC to 10 MHz	†	20 mV_{rms} typ	20 mV_{rms} typ

† depends on user supply
†† relative to input voltage
††† includes +5 V efficiency

Physical

Screw terminal..24 to 16 AWG

Power Requirement

Voltage..7 to 42 VDC max

Reverse voltage protection ....–42 VDC max

Power ....325 mA at 12 VDC

SCC-A10 Buffered Voltage Attenuator

Analog Input

Number of input channels.......................2 DIFF

Input range ....±100 VDC
each input should remain within
±100 V of ground

Input impedance ....1 MΩ (powered on or off)

Overvoltage protection ....Up to 250 VDC/AC

Gain error...±0.14% max[2]

Gain stability...±0.006%/°C max[3]

Offset error ....±6.5 mV max[3] (referred to input)

Stability...±80 µV/°C max[3] (referred to input)

Nonlinearity ....±0.004%

Common-mode rejection ratio................60 dB min at 60 Hz

Dynamic Response

Bandwidth (–3 dB, amplitude ≤1 V) ......1 MHz

Output slew rate.....................................0.75 V/µs min

Power Requirement

Analog power .... 100 mW max[3]
    (+15 V .... 3.2 mA max)
    (–15 V .... 3.2 mA max)

Digital power (+5 V)............................. 0.0 mA

Physical

Dimensions... 8.89 by 2.92 by 1.85 cm
(3.5 by 1.15 by 0.73 in.)

I/O connectors .... 1, 20-pin right-angle
male connector
1, 4-pin screw terminal system

Screw terminal .... 24 to 12 AWG

Environment

Operating temperature........................... 0 to 50 °C

Storage temperature .... –55 to 125 °C

Relative humidity .... 5 to 90% noncondensing

SCC-AI*XX* Isolated Analog Input

Number of input channels .... 2 NRSE

Isolation... bank isolation (isolation per
module)

Input/output signal range, gain, and bandwidth

See Table4-1, *SCC-AIXX Module Input/Output Range, Gain, and Bandwidth*.

Input impedance .... 1 MΩ (SCC-AI01,SCC-AI02)
100 MΩ (all others)

Safety isolation
- Working voltage ....300 V, Category II
- Differential maximum voltage ....250 VDC/AC

Gain error..4.5% max[4]

Gain stability..150 PPM/°C

Offset error ....40 mV max[4] (referred to input)

Offset stability ....225 µV/°C

Nonlinearity ....0.0128% typical
0.0260% max

Common-mode rejection ratio................100 dB typical at 60 Hz

Output slew rate,
dependent on BW (filtering)...................0.8 V/µs max

Power Requirement

Analog power ....260 mW max
- +15 V ....8.67 mA max
- –15 V ....8.67 mA max

Digital power (+5 V) ....255 mW max
51 mA max

Physical

Dimensions ....8.89 by 2.92 by 1.85 cm
(3.5 by 1.15 by 0.73 in.)

I/O connectors..1, 20-pin right-angle
male connector
1, 4-pin screw terminal system

Screw terminal ....24 to 12 AWG

Environmental

Operating temperature .... 0 to 50 °C

Storage temperature .... –55 to 125 °C

Relative humidity .... 5 to 90% noncondensing

SCC-CI20 Buffered Current Input

Analog Input

Number of input channels .... 2 DIFF

Input range .... 0 to 20 mA

Input resistor

- Value .... 249 Ω
- Tolerance 0.05%
- TCR .... 10 ppm/°C
- Max power dissipation .... 0.25 W

Absolute max input current .... 32 mA

Absolute maximum voltage
on CH+ and CH– .... ±15 V

Output range .... 0 to +5 V

Output slew rate .... 0.75 V/µs min

Gain error .... ±0.1% max[2]

Gain stability .... ±0.006%/°C max[3]

Offset error .... ±0.6 mV max[2]

Offset stability .... ±21 µV/°C max[3]

Dynamic Response

Bandwidth (–3 dB, amplitude ≤1 V) ...... 1 MHz

Output slew rate .... 0.75 V/µs min

Power Requirement

Analog power ....100 mW max
+15 V ....3.2 mA max[3]
–15 V ....3.2 mA max[3]

Digital power (+5 V) ....0.0 mW

Physical

Dimensions ....8.89 by 2.92 by 1.85 cm
(3.50 by 1.15 by 0.73 in.)

I/O connectors..1, 20-pin right-angle
male connector
1, 4-pin screw terminal system

Screw terminal.......................................28 to 16 AWG

Environment

Operating temperature ....0 to 50 °C

Storage temperature................................–55 to 125 °C

Relative humidity ....5 to 90% noncondensing

SCC-ICP01 Integrated Circuit Piezoelectric Input

Analog Input

Number of input channels.......................1 differential

Input range...±5 VAC (fixed gain of 2)

Input coupling..AC
–3 dB cutoff frequency....................0.8 Hz

Filter type..Lowpass 3-pole Bessel
–3 dB cutoff frequency....................19 kHz

Passband flatness ....±0.3 dB, 10 Hz–5 kHz
±1 dB, 5 Hz–10 kHz

Maximum working voltage (signal + common mode)	Each input should remain within ±12 V of ground
Overvoltage protection	±40 VAC + DC (powered on or off)
Input impedance	0.39 μF in series with 5 MΩ (powered on or off)
System noise	130 μV_{rms} (referred to input)

Transfer Characteristics

Gain	25
Gain error	±1%
Gain-error temperature coefficient	±10 ppm/°C
Offset error	±3 mV RTI
Offset-error temperature coefficient	±1.6 μV/°C
Nonlinearity	10 ppm of full scale
Recommended warm-up time	5 minutes

Amplifier Characteristics

CMRR	80 dB at 60 Hz
Output range	±10 V

Excitation

Number of channels	1
Constant-current source	4 mA
Maximum voltage level without losing regulation	24 V
Drift	±127 ppm/°C

Power Requirement

Analog power ....128 mW max
+15 V ....4.3 mA max
–15 V ....4.3 mA max

Digital power ....150 mW max
+5 V ....30 mA max

Physical

Dimensions ....8.89 by 2.92 by 1.85 cm
(3.50 by 1.15 by 0.73 in.)

I/O connectors.......................................1, 20-pin right-angle
male connector,
1, 6-pin screw terminal

Field-wiring diameter ....28 to 16 AWG

Environment

Operating temperature ....0 to 50 °C

Storage temperature ....–55 to 125 °C

Relative humidity ....5 to 90% noncondensing

SCC-LP Lowpass Filter

Amplifier Characteristics

Number of input channels.......................2 differential

Input signal range ....±10 V

Output signal range................................±5 V

Gain 0.5

Overvoltage protection ....±40 V

Input impedance ....10 GΩ parallel 10 pF powered on
10 kΩ powered off or overloaded

Gain error .... Adjustable to 0%

Offset error (RTI)................................... 350 µV typ
1.5 mV max[5]

Input bias current .... ±2 nA typ
±5 nA max[5]

Filter Characteristics

Filter type .... Fourth-order Butterworth

Rolloff rate .... 80 dB/decade

Cutoff frequency Fc (–3 dB)

SCC-LP01 .... 25 Hz
SCC-LP02 .... 50 Hz
SCC-LP03 .... 150 Hz
SCC-LP04 .... 1 kHz

Passband ripple

	Typical	**Maximum**
DC to 1/3 Fc	±0.04 dB	0 ±0.1 dB
DC to 1/2 Fc	±0.06 dB	0 ±0.2 dB
DC to 2/3 Fc	–0.2 ±0.25 dB	–0.2 ±0.4 dB
DC to Fc	–3 ±0.3 dB	–3 ±0.5 dB

System Noise

THD at Fc.. < –90 dB

Wide band noise
(DC to 1 MHz, RTI).............................. 100 μV_{rms}

Narrow band noise
(DC to 33 kHz, RTI) .... 6 μV_{rms}

Stability

Gain temperature coefficient ....10 ppm/°C typ
20 ppm/°C max

Offset drift (RTI) ....3.4 µV/°C typ
27 µV/°C max

Power Requirement

Analog power ....132 mW max
+15 V ....4.4 mA max
–15 V ....4.4 mA max

Digital power ....0.0 mW max
+5 V ....0.0 mA max

Physical

Dimensions ....8.89 by 2.92 by 1.85 cm
(3.50 by 1.15 by 0.73 in.)

I/O connectors... 1, 20-pin right-angle
male connector
1, 4-pin screw terminal

Field-wiring diameter ....28 to 16 AWG

Environment

Operating temperature .... 0 to 50 °C

Storage temperature................................–55 to 125 °C

Relative humidity ....5 to 90% noncondensing

SCC-RTD01 Resistance-Temperature Detector Input

Analog Input

Number of input channels	2 differential
Input range	±400 mVDC (fixed gain of 25 on each channel)
Maximum working voltage (signal + common mode)	Each input should remain within ±12 V of ground
Overvoltage protection	±42 V (powered on or off)
Input impedance	1 MΩ in parallel with 4.7 nF (powered on or off)
Filter type	Lowpass 3-pole Sallen & Key filter
–3 dB cutoff frequency	30 Hz
System noise	4.5 μV_{rms} (referred to input)

Transfer Characteristics

Gain	25
Gain error	±1.2%
Gain-error temperature coefficient	±10 ppm/°C
Offset error	±250 µV RTI
Offset-error temperature coefficient	±1.6 µV/°C
Nonlinearity	10 ppm of full scale
Recommended warm-up time	5 minutes

Amplifier Characteristics

CMRR	110 dB at 60 Hz
Output range	±10 V

Excitation

Number of channels................................1

Constant-current source..........................1 mA, ±0.4 µA or 0.04%

Maximum voltage level
without losing regulation........................24 V

Drift ....±127 ppm/°C

Power Requirement

Analog power ....128 mW max
+15 V...4.3 mA max
–15 V ....4.3 mA max

Digital power..125 mW max
+5 V...25 mA max

Physical

Dimensions ....8.89 by 2.92 by 1.85 cm
(3.50 by 1.15 by 0.73 in.)

I/O connectors...1, 20-pin right-angle
male connector,
1, 6-pin screw terminal

Field-wiring diameter ....28 to 16 AWG

Environment

Operating temperature ....0 to 50 °C

Storage temperature................................–55 to 125 °C

Relative humidity ....5 to 90% noncondensing

SCC-SG0*X* Strain Gauges

Analog Input

Number of strain gauge channels	2 DIFF
Input signal ranges	±100 mV (fixed gain of 100 on each channel)
Maximum working voltage (signal + common mode)	Each input should remain within ±12 V of ground
Overvoltage protection	±60 V powered on and powered off
Input impedance	
Normal powered on	10 MΩ
Powered off or overload	10 kΩ
Bandwidth	1.6 kHz (single-pole RC filter)
System noise	1 μV_{rms} (referred to input)

Transfer Characteristics

Gain	100
Gain error	±0.8% max[2]
Gain temperature coefficient	±5 ppm/°C[3]
Offset error	±5 µV (post calibration)[2]
Offset temperature coefficient	±0.6 µV/°C[3]
Offset nulling range	±2.5 mV (referred to input)
Nonlinearity	10 ppm of FS
Recommended warm-up time	5 minutes

Amplifier Characteristics

CMRR	110 dB min
Output range	±10 V max

Excitation

Number of channels	1
Level	2.5 V, ±0.4%
Current drive	42 mA[6]
Drift	13 mV/°C

Bridge Type

SCC-SG01	Quarter-bridge, 120 Ω
SCC-SG02	Quarter-bridge, 350 Ω
SCC-SG03	Half-bridge
SCC-SG04	Full-bridge

Bridge Completions

Quarter-bridge	One 120 Ω 1/4 W, 0.1% tolerance, 10 ppm/°C *or* One 350 Ω 1/4 W, 0.1% tolerance, 10 ppm/°C
Half-bridge	Two 10 kΩ, ±0.02% ratio tolerance, ±2 ppm/°C tracking TCR resistors

Completion Accuracy

Half-bridge completion reference	1.25 V, ± 0.4%

Power Requirement

Analog power	143 mW max
+15 V	4.75 mA max
–15 V	4.75 mA max
Digital power	105 mW max
+5 V	21 mA max

Physical

Dimensions .... 8.89 by 2.92 by 1.85 cm
(3.50 by 1.15 by 0.73 in.)

I/O connectors .... One 20-pin right-angle
male connector
One 6-pin screw terminal

Screw terminal .... 28 to 16 AWG

Environment

Operating temperature........................... 0 to 50 °C

Storage temperature .... –55 to 125 °C

Relative humidity .... 5 to 90% noncondensing

SCC-SG11 Strain Gauge

Digital I/O

Number of channels 1

Shunt Calibration

Number of channels 2

Resistor for each channel .... 301 kΩ ±1%, socketed

Resistor temperature coefficient .... ±100 ppm/°C

Max voltage across channel .... ±12 V

Power Requirements

Analog power .... 0.1 mW max
+15 V .... 5 µA max
–15 V .... 5 µA max

SCC-TC01/02 Thermocouple

Analog Input

Number of thermocouple input channels ....1 DIFF

Input signals...Thermocouples of types B, E, J, K, N, R, S, and T

Input signal range ....±100 mV

Max working voltage (signal + common mode) ....Each input should remain within ±12 V of chassis ground

Input damage level.................................60 VAC/DC[7]

Input impedance ....10 MΩ powered on
10 kΩ powered off or overload

Bandwidth..2 Hz

Amplifier Characteristics

Open thermocouple detection current.....250 nA max[2] (assuming floating thermocouple)

Common-mode rejection ratio................110 dB min[2]

Output range ....±10 V max[2]

Transfer Characteristics

Gain 100

Gain error...±0.08% max[2]

Gain stability..±0.0005%/°C max[3]

Offset error ....±5 μV max (post calibration)[2]

Offset stability ....±0.6 μV/C max[3]

Nonlinearity .... ±0.004% max[2]

Recommended warm-up time .... 5 minutes

Measurement Accuracy [8]

Thermocouple Type	Temperature Range (°C)	Maximum (±°C)	Typical (±°C)
B	400 to 600 600 to 1800	2.5 2	0.31 0.13
E	–200 to –100 –100 to 600 600 to 1000	2 1 1.5	1.76 1 0.6
J	–200 to –100 –100 to 500 500 to 1100	2 1 1.5	1.6 0.9 0.72
K	–200 to –100 –100 to 600 600 to 1200	2.5 1.25 2	1.25 0.67 0.45
N	–200 to –100 –100 to 1300	2.5 2	2 0.7
R	–50 to 0 0 to 100 100 to1600	3 2 1.75	1.24 0.82 0.4
S	–50 to 0 0 to 1400 1400 to 1600	3 2 2.5	1.3 1 1
T	–200 to –100 –100 to 400	2.5 1	2 0.9

Cold-Junction Sensor

Cold-junction sensor accuracy................±0.4° max from 15 to 35 °C, ±0.75° max from 0 to 15 °C and 35 to 55 °C

Output ....1.91 V (0 °C) to 0.58 V (55 °C)

Note The accuracy specification includes the combined effects of the temperature sensor accuracy and the temperature difference between the temperature sensor and any thermocouple connector. The temperature sensor accuracy includes component tolerances, temperature drifts, and self-heating effects. It does not include measurement device errors.

Open Thermocouple Detection

Pull-up resistor.......................................10 MΩ

Bias resistor ....10 MΩ

Maximum field wire gauge.....................28 to 16 AWG

Power Requirement

Analog power ....114 mW max

+15 V...3.5 mA max

–15 V ....3.5 mA max

Digital power (+5 V) ....0.0 mW

Physical

TC01 dimensions....................................7.8 by 2.92 by 1.85 cm (3.1 by 1.15 by 0.73 in.)

TC02 dimensions....................................8.89 by 2.92 by 1.85 cm (3.50 by 1.15 by 0.73 in.)

I/O ....1, 20-pin right angle male connector, 3-pin screw terminal system (SCC-TC02), 2-prong mini-connector (SCC-TC01)

Screw terminal (SCC-TC02) ....28 to 16 AWG

Environment

Operating temperature............................ 0 to 50 °C

Storage temperature .... –55 to 125 °C

Relative humidity.................................. 5 to 90% noncondensing

SCC-FT01 Feedthrough

Analog

Number of input channels...................... 1 DIFF or 2 SE (when plugged into an AI socket on the SC-2345)

Number of output channels.................... 1 (when plugged into an AO socket on the SC-2345)

Power Requirement

No power required

Physical

Dimensions.. 8.89 by 2.92 by 1.85 cm (3.50 by 1.15 by 0.73 in.)

I/O connectors .... 1, 20-pin right-angle male connector
1, 6-pin screw terminal system

Screw terminal .... 28 to 16 AWG

SCC-DI01 Isolated Digital Input

Input Characteristics

Number of channels................................1

Maximum input voltage..........................30 VDC or 30 VAC

Digital logic levels

Level	Min	Max
Input low voltage (DC or Peak AC)	—	±1 V
Input high voltage DC 1 kHz AC	 ±2 VDC 4 V_{rms}	 ±30 VDC 24 VAC

Input current
- 5 V input..1.5 mA
- 24 V input..7.0 mA

Isolation ....24 VDC from computer ground

Propagation delay
- Low to high......................................10 µs typ[9]
- High to low ....250 µs typ[9]

Rise time ....10 ns max

Fall time..10 ns max

Power Requirement

Digital power ....61 mW max
- +5 V ....12 mA max

SCC-DO01 Isolated Digital Output

Output Characteristics

Compatibility .... TTL-compatible

Number of channels 1

Supply voltage range.............................. 5 to 24 VDC

Digital logic levels

Level	Min	Max
Output low voltage (I_{OL} = 25 mA)	—	.4 V
Output high voltage (I_{OH} = 25 mA)	22 VDC at V_{SS} = 24 V 3 VDC at V_{SS} = 5 V	— —

Maximum out current on any pin........... 120 mA

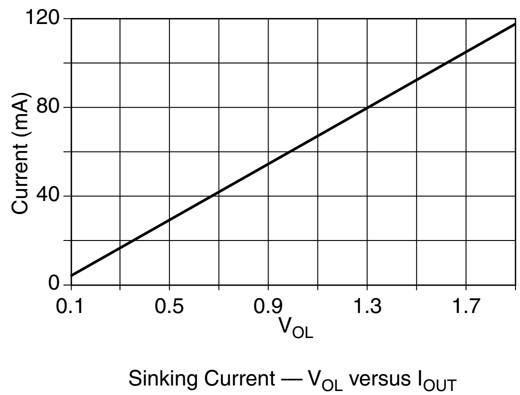


Figure A-1. Maximum Sinking Characteristics

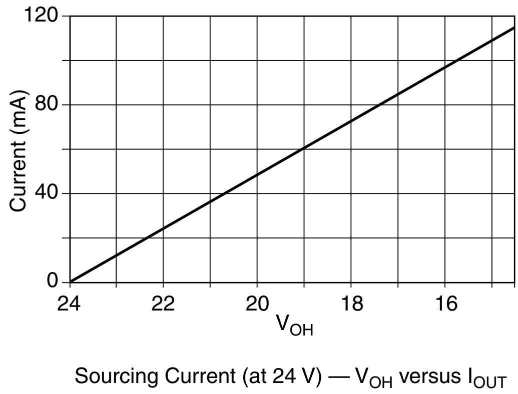


Figure A-2. Maximum Sourcing Characteristics

Supply current for isolated outputs
- 5 V input .... 1 mA
- 24 V input .... 5 mA

Isolation .... 24 VDC from computer ground

Propagation delay
- Low to high..................................... 400 µs typ[9]
- High to low .... 300 µs typ[9]

Rise time .... 120 µs typ

Fall time... 25 µs typ

Power Requirement

Digital power.. 69 mW max

+5 V .... 13 mA max

---

1 These numbers exclude the SCC requirements.

2 Temperature range is 23 °C ±5 °C.

3 Temperature range is 0 to 50 °C.

4 Trimable to zero.

5 Applicable at 25 °C.

6 Excitation current drive assumes two full-bridge 120 Ω strain gauges.

7 The SCC-TC01/02 is not designed for high-voltage use. Voltages greater than ±40 V may be hazardous.

8 Total system measurement error for operating temperature within ±5 °C of calibration temperature. Includes PCI/AT-MIO-16XE-50 one year accuracy specification of 0.01% ±412 µV. SCC-TC01/02 accuracy specification of 0.08% ±5 µV, and reference junction measurement accuracy of 0.5 °C. Assumes averaging. Non-averaged, single-point reading will have an additional uncertainty (up to ±0.1 °C for J type thermocouple).

9 The switching characteristics (turn-on time, switching time, and turn-off time) of the optical isolator used on the board limits the data transfer rate.

B

SCC Feature Reference Table

This appendix provides a concise overview of the features of each SCC module.

Table B-1. Analog Input

Module	Number of Channels	Input Range	Differential Measurement	Buffered Input	Single-Stage AI	First-Stage of Dual-Stage AI	Second-Stage of Dual-Stage AI	Analog Power Requirements	Digital Power Requirements	Power Category
SCC-A10	2	±100 V	Yes	Yes	Yes	Yes	No	100 mW	No	Low
SCC-AI*XX*	2	†	No	Yes	Yes	Yes	No	260 mW	255 mW	High
SCC-CI20	2	0 to 20 mA	Yes	Yes	Yes	Yes	Yes	100 mW	No	Low
SCC-IICP 01	1	±5 V	Yes	Yes	Yes	Yes	No	89 mW	150 mW	Low
SCC-LP	2	±10 V	Yes	Yes	Yes	Yes	Yes	132 mW	No	Medium
SCC-RTD 01	2	±0.4	Yes	Yes	Yes	Yes	No	128 mW	125 mW	Medium
SCC-SG0*x*	2	±100 mV	Yes	Yes	Yes	No	No	143 mW	105 mW	Medium
SCC-SG11	2	±12 V	N/A	N/A	No	Yes	No	0.1 mW	No	Low
SCC-TC	1	±100 mV (–200 °C to 1800 °C dependent on thermocouple)	Yes	Yes	Yes	No	No	114 mW	No	Low
SCC-FT01	2	±10 V	No	No	Yes	Yes	No	No	No	Low
SCC-FT01 (Prototype Version)	2	±10 V	User-defined	User-defined	User-defined	User-defined	User-defined	User-defined	User-defined	User-defined

† Refer to the section *SCC-AI Series Isolated Analog Input Modules* in Chapter 4, *SCC Series Modules*, for input range values of each module.

Table B-2. Analog Output

Features	SCC-FT01	SCC-FT01 (Prototype Version)
Number of Channels	1	2
Output range	±10 V	±10 V
Analog power requirements	No	User-defined
Digital power requirements	No	User-defined
Power category	Low	User-defined

Table B-3. Digital I/O

Features	SCC-DI01	SCC-DO01	SCC-FT01 (Prototype Version)
Number of channels	1	1	User-defined
Drive current	No	±25 mA	User-defined
Working voltage	5 to 24 V	5 to 24 V	User-defined
Analog power requirements	No	No	User-defined
Digital power requirements	61 mW	69 mW	User-defined
Power category	Low	Low	User-defined

Table B-4. GPCTR

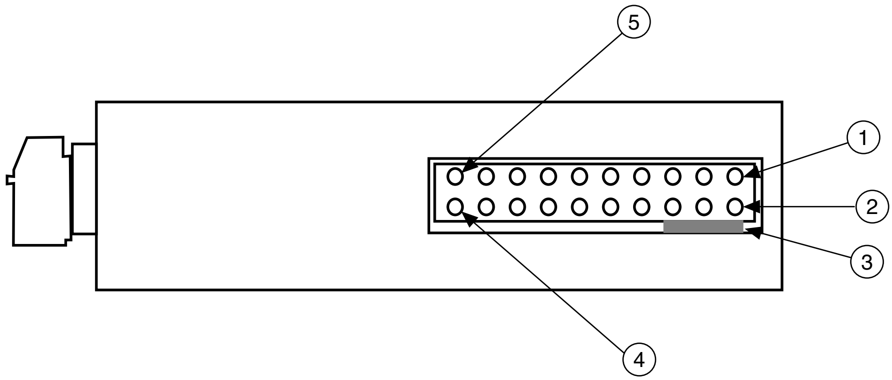
Features	SCC-FT01	SCC-FT01 (Prototype Version)
Number of channels	No	User-defined
Analog power requirements	No	User-defined
Digital power requirements	No	User-defined
Power category	Low	User-defined

C

SCC I/O Connector Pin Information

This appendix gives the I/O connector pinout for SCC modules and is provided for you if you are designing a custom backplane for use in place of the SC-2345.

Figure C-1 illustrates the I/O connector pin numbers and Tables C-1 and C-2 list the signal connection corresponding to each pin in a particular module.



1 Pin 1	2 Pin 2	3 PWB Key	4 Pin 20	5 Pin 19

Figure C-1. SCC Module Bottom View

Table C-1. SCC Module Pin Signal Connections for A10, AI*XX*, CI20, DI01, DO01, and FT01 Modules

Pin Number	A10	AI*XX*	CI20	DI01	DO01	FT01
1	ACH(*X*)	ACH(*X*)	ACH(*X*)	—	—	ACH(*X*)
2	—	—	—	—	—	—
3	—	—	—	—	—	—
4	ACH(*X*+8)	ACH(*X*+8)	ACH(*X*+8)	—	—	ACH(*X*+8)
5	—	—	—	—	—	—
6	AIGND	AIGND	AIGND	—	—	AIGND
7	—	—	—	DIO(*X*)	DIO(*X*)	—
8	—	—	—	—	—	—
9	—	+5V	—	+5V	+5V	—
10	—	GND	—	GND	GND	—
11	AGND	AGND	AGND	—	—	—
12	—	REF5V	—	—	—	—
13	+15V	+15V	+15V	—	—	—
14	–15V	–15V	–15V	—	—	—
15	—	—	—	—	—	—
16	—	—	—	—	—	—
17	—	—	CH(*X*) – Input	—	—	—
18	—	—	CH(*X*+8) + Input	—	—	—
19	—	—	CH(*X*) + Input	—	—	—
20	—	—	CH(*X*+8)– Input	—	—	—

Notes:
AIGND and AGND connect on the SC-2345 at the SCC-PWR connector.
AIGND is the reference for ACH(X) and ACH(X+8).
AGND is the reference for the ±15 V supplies and REF5V.
GND is the reference for the +5V supply.
You can use pins 17 through 20 for cascading channels.

Table C-2. SCC Module Pin SIgnal Connections for ICP01, LP*XX*, RTD01, SG0*X*, SG11, and TC*XX* Modules

Pin Number	ICP01	LP*XX*	RTD01	SG0*X*	SG11	TC*XX*
1	ACH(*X*)	ACH(*X*)	ACH(*X*)	ACH(*X*)	—	ACH(*X*)
2	—	—	—	—	—	—
3	—	—	—	—	—	—
4	—	ACH(*X*+8)	ACH(*X*+8)	ACH(*X*+8)	—	ACH(*X*+8)
5	—	—	—	—	—	—
6	AIGND	AIGND	AIGND	AIGND	—	AIGND
7	—	—	—	—	DIO(*X*)	—
8	—	—	—	—	—	—
9	+5V	—	+5V	+5V	+5V	—
10	GND	—	GND	—	GND	—
11	AGND	AGND	AGND	AGND	AGND	AGND
12	—	—	—	REF5V	—	REF5V
13	+15V	+15V	+15V	+15V	+15V	+15V
14	–15V	–15V	–15V	–15V	–15V	–15V
15	—	—	—	—	—	—
16	—	—	—	—	—	—
17	—	CH(*X*) – Input	—	CH(*X*) – Input	—	—
18	—	CH(*X*+8) + Input	—	CH(*X*+8) + Input	—	—
19	—	CH(*X*) + Input	—	CH(*X*) + Input	—	—
20	—	CH(*X*+8) – Input	—	CH(*X*+8) – Input	—	—

Notes:
AIGND and AGND connect on the SC-2345 at the SCC-PWR connector.
AIGND is the reference for ACH(X) and ACH(X+8).
AGND is the reference for the ±15 V supplies and REF5V.
GND is the reference for the +5V supply.
You can use pins 17 through 20 for cascading channels.

D

Technical Support Resources

Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of `ni.com`

NI Developer Zone

The NI Developer Zone at `ni.com/zone` is the essential resource for building measurement and automation systems. At the NI Developer Zone, you can easily access the latest example programs, system configurators, tutorials, technical news, as well as a community of developers ready to share their own techniques.

Customer Education

National Instruments provides a number of alternatives to satisfy your training needs, from self-paced tutorials, videos, and interactive CDs to instructor-led hands-on courses at locations around the world. Visit the Customer Education section of `ni.com` for online course schedules, syllabi, training centers, and class registration.

System Integration

If you have time constraints, limited in-house technical resources, or other dilemmas, you may prefer to employ consulting or system integration services. You can rely on the expertise available through our worldwide network of Alliance Program members. To find out more about our Alliance system integration solutions, visit the System Integration section of `ni.com`

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If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. Phone numbers for our worldwide offices are listed at the front of this manual.

Glossary

Prefix	Meanings	Value
p-	pico-	10^{-12}
n-	nano-	10^{-9}
μ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}
G-	giga-	10^{9}

Symbols

%	percent
+	positive of, or plus
/	per
°	degree
Ω	ohm
ε	strain
α	RTD temperature coefficient (Ω/Ω/°C)

A

A	amperes
ACH	analog input channel signal
AIGND	analog input ground signal
AISENSE	analog input sense signal

amplification	a type of signal conditioning that improves accuracy in the resulting digitized signal and reduces noise
AOGND	analog output ground signal
attenuate	to decrease the amplitude of a signal
AWG	American Wire Gauge

B

bandwidth	the range of frequencies present in a signal, or the range of frequencies to which a measuring device can respond
break-before-make	a type of switching contact that is completely disengaged from one terminal before it connects with another terminal
BW	bandwidth

C

C	Celsius
cascading	the process of extending the counter range of a counter chip by connecting to the next counter
CH	channel
channel	pin or wire lead to which you apply or from which you read the analog or digital signal. Analog signals can be single-ended or differential. For digital signals, you group channels to form ports. Ports usually consist of either four or eight digital channels.
CMRR	common-mode rejection ratio—a measure of the ability of an instrument to reject interference from a common-mode signal, usually expressed in decibels (dB)
cold-junction compensation	a method of compensating for inaccuracies in thermocouple circuits
common-mode range	the input range over which a circuit can handle a common-mode signal

common-mode signal	the mathematical average voltage, relative to the computer's ground, of the signals from a differential input
common-mode voltage	any voltage present at both instrumentation amplifier inputs with respect to amplifier ground
counter/timer	a circuit that counts external pulses or clock pulses (timing)

D

DAC	digital-to-analog converter—an electronic device, often an integrated circuit, that converts a digital number into a corresponding analog voltage or current
DAQ	data acquisition—(1) collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and inputting them to a computer for processing; (2) collecting and measuring the same kinds of electrical signals with A/D and/or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer
dB	decibel—the unit for expressing a logarithmic measure of the ratio of two signal levels: dB = 20log10 V1/V2, for signals in volts
DC	direct current
device	a plug-in data acquisition board, card, or pad that can contain multiple channels and conversion devices. Plug-in boards, PCMCIA cards, and devices such as the DAQPad-1200, which connects to your computer parallel port, are all examples of DAQ devices. SCXI modules are distinct from devices, with the exception of the SCXI-1200, which is a hybrid.
DIFF	differential mode
DIO	digital input/output
DIP	dual inline package

E

EMI	electromagnetic interference
EXTREF	external reference signal
EXTSTROBE	external strobe signal

F

F_c	frequency cutoff
filtering	a type of signal conditioning that allows you to filter unwanted signals from the signal you are trying to measure
floating signal sources	signal sources with voltage signals that are not connected to an absolute reference or system ground. Also called nonreferenced signal sources. Some common examples of floating signal sources are batteries, transformers, or thermocouples.
FREQ_OUT	frequency output signal

G

g	a unit of acceleration equal to 9.80 m/s^2
gain	the factor by which a signal is amplified, sometimes expressed in decibels
gain error	a measure of deviation of the gain of an amplifier from the ideal gain
GPCTR0_GATE	general purpose counter timer 0 gate signal
GPCTR1_GATE	general purpose counter timer 1 gate signal
GPCTR0_OUT	general purpose counter timer 0 output signal
GPCTR1_OUT	general purpose counter timer 1 output signal
GPCTR0_SOURCE	general purpose counter timer 0 clock source signal
GPCTR1_SOURCE	general purpose counter timer 1 clock source signal

H

h	hour
hardware	the physical components of a computer system, such as the circuit boards, plug-in boards, chassis, enclosures, peripherals, cables, and so on
Hz	hertz—the number of scans read or updates written per second

I

input bias current	the current that flows into the inputs of a circuit
input impedance	the measured resistance and capacitance between the input terminals of a circuit
input offset current	the difference in the input bias currents of the two inputs of an instrumentation amplifier
instrumentation	a circuit whose output voltage with respect to ground is proportional to
amplifier	the difference between the voltages at its two inputs
I/O	input/output—the transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces

K

K	kelvin

L

LabVIEW	laboratory virtual instrument engineering workbench
LED	light-emitting diode

N

NC	normally closed, or not connected
NI-DAQ	National Instruments driver software for DAQ hardware
NIST	National Institute of Standards and Technology
NMR	normal mode rejection
NO	normally open
noise	an undesirable electrical signal—noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are trying to send or receive.
nonlinearity	For an amplifier, a measure of the maximum output deviation from an ideal linear response in units of percent relative to full scale. The ideal linear response is taken to be a straight line on a plot of measured output voltage to measured input voltage with the ends of the line connecting the extremes of the plot at the full-scale limits.
NRSE	nonreferenced single-ended mode—all measurements are made with respect to a common (NRSE) measurement system reference, but the voltage at this reference can vary with respect to the measurement system ground

O

offset error	a measure of deviation of the offset of an amplifier from the ideal offset; the output of a system with a zero-volt input

P

P_A	analog power
P_D	digital power
pad	a hole in the PWB used by the customer for signal connection

peak to peak	a measure of signal amplitude; the difference between the highest and lowest excursions of the signal
PFI	Programmable Function Input
potentiometer	an electrical device in which the resistance can be manually adjusted; used for manual adjustment of electrical circuits and as a transducer for linear or rotary position
ppm	parts per million

R

referenced signal sources	signal sources with voltage signals that are referenced to a system ground, such as the earth or a building ground. Also called grounded signal sources.
ringing	oscillatory transient behavior
rms	root mean square—the square root of the average value of the square of the instantaneous signal amplitude; a measure of signal amplitude
RSE	referenced single-ended mode—all measurements are made with respect to a common reference measurement system or a ground. Also called a grounded measurement system.
RTI	referred to input

S

s	seconds
scan	one or more analog or digital input samples. Typically, the number of input samples in a scan is equal to the number of channels in the input group. For example, one pulse from the scan clock produces one scan which acquires one new sample from every analog input channel in the group.
SCANCLK	scan clock signal
scan rate	the number of scans per second. For example, a scan rate of 10 Hz means sampling each channel 10 times per second.
SCC	signal conditioning component

SCC-LP	refers to all versions in the LP series
SCC-PWR	refers to an SCC power module
SCC-TC	refers to both the SCC-TC01 and the SCC-TC02
SE	single-ended—a term used to describe an analog input that is measured with respect to a common ground
sensor	a device that responds to a physical stimulus (heat, light, sound, pressure, motion, flow, and so on), and produces a corresponding electrical signal
signal conditioning	the manipulation of signals to prepare them for digitizing
source impedance	a parameter of signal sources that reflects current-driving ability of voltage sources (lower is better) and the voltage-driving ability of current sources (higher is better)
STARTSCAN	start scan signal
system noise	a measure of the amount of noise seen by an analog circuit or an ADC when the analog inputs are grounded

T

TCR	temperature coefficient of resistance
THD	total harmonic distortion—the ratio of the total rms signal due to harmonic distortion to the overall rms signal, in decibels or percent
thermistor	a semiconductor sensor that exhibits a repeatable change in electrical resistance as a function of temperature. Most thermistors exhibit a negative temperature coefficient.
thermocouple	a temperature sensor created by joining two dissimilar metals. The junction produces a small voltage as a function of the temperature.
TRIG	trigger signal
trimpot	a potentiometer used to adjust channel gain or offset

U

UPDATE	update signal

V

V	volts
V_{COM}	voltage input signal reference
V_{DC}	volts direct current
V_{IN}	voltage input signal
V_{SS}	voltage supply signal

W

W	watts
WFTRIG	waveform generation trigger signal
working voltage	the highest voltage that should be applied to a product during normal use, normally well under the breakdown voltage for safety margin

Index

M

N

O

P

R

S